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ON THE DEVELOPMENT OF A PARASITIC COPEPOD, *Lernaea elegans* LEIGH-SHARPE, INFESTING ON *Cyprinus carpio* L.

(With 7 Text figures and Plate II–IV.)

By

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A considerable number of eels had been destroyed by this parasite in a fish cultural pond near the city of Toyohashi, Prefecture Aichi, in 1922, and many informations respecting the infection were reported from various districts of the central Japan. With this cause, indeed, our culture of the fresh water fish had always been threatened. In order to prevent the disease, the preliminary examination has, since last autumn, been undertaken, and the life history and some of the biological accounts, which are given here, are determined in the first place.

The present species was described by Leigh-Sharpe (4) as *Lernaea elegans* n. sp. in 1925, but the first record on the Lernaean infection in Japan was made by Ishii (2) in 1915, who wrote about *Lernaeocera cyprinacea* (L.) infesting on the crucian carp.

Fig. 1. The posterior part of the diseased carp infested with adult female worms. × $\frac{1}{1}$

The Habit.

The adult females seriously infest not only on the cultured fishes as *Anguilla japonica* T. & S., *Cyprinus carpio* L. and *Carassius auratus* (L.) (gold fish), but also on the wild fishes living near the fish cultural pond as *Oryzias latipes* (T. & S.),

Pseudorasbora parva (T. & S.), *Carassius auratus* (L.), *Misgurnus anguillicaudatus* Cantor., *Chaenogobius macrognathos* (Bleeker), *Plecoglossus altivelis* T. & S., etc.

In the case of the eel and the loach, the parasites are so crowded often in the buccal cavity that no food is allowded to swallow (Text fig. 3), vice versa in the other fishes, i.e., parasite infests freely on the skin, but rarely in the buccal cavity (Textfigs. 1–2). In the incipient stage of the parasitism, the surrounding tissue is profoundly modified and often forms the congestive swelling, from which the posterior part of the worm projects. The patient loosing the appetite becomes haggard aspect exceedingly and die within a few weeks.

Fig. 2. The buccal cavity of the diseased carp infested with adult female worms. × $\frac{1}{1}$

Although the parasites are found throughout the year, the dangerous season for the fish culture is in early June to early October, which is nearly consistent with Wilson's description (6, pp. 190) upon the larvae of *Lernaea variavilis* infesting on the gills of the short-nosed gar. Such a seasonal variation of the parasites has, no doubt, an intimate relation to the water temperature which offer the suitable condition for the propagation of the parasites as it is explained in the following chapter.

Fig. 3. The buccal cavity of the diseased eel infested with adult female worms. × $\frac{1}{1}$

As to the host, Wilson (6, pp. 171) states that " .....every species of Lernaea has at least two hosts widely differing from each other. One of these serves as the temporary host of the copepodid larvae, the other as the final or permanent host of the adult female ; " while in the case on the carps which were seriously infested with the adult females, a marked number of the copepodid larvae were found in the different states of develop-

ment in the mucous layer of the skin as shown on the following table:

TABLE I. The percentage of the copepodid larvae infesting on the diseased carp.

Developing stages of larvae.	1st copep.	2nd copep.	3rd copep.	4th copep.	5th copepod.		Total number examined.
					♂	♀	
Percentage of larvae infested.	1%	6	6	20	50	17	852

Remarks: The third copepodid stage, having the intermediate construction between Wilson's second and third ones, is newly added and in consequence the present fourth and fifth stages correspond to his third and fourth ones. The descriptions of respective stages are given in the later part of this work.

Accordingly the final host seems to serve as the temporary one at the same time, but there infest but a few of the younger larvae and in the case of a slight infection they are seldom found on the carp; and moreover, no larva has ever, so far as I know, been observed on the skin of the eel. Hence I may infer that the present species may also require such a temporary host of the copepodid larvae as Wilson describes, and I am in search of it. This fact as well as the adult female why usually infests in the buccal cavity of the eel and the loach, may give very interesting and important problem in the study of the habitual accounts of the present species.

The influence of the water temperature on the hatching of eggs and on the early larval stages.

The diseased carps from which the material for this experiment was taken, were sent me in their living state from one of the fish cultural stations near Tokyo on 15th Sept., last year. They attained 22–25 cm. in total length and were in very poor condition, being heavily infested with parasites on body. (Textfig. 1)

The infection was at first observed in early June, giving the greatest damage in August, and ceased in the end of October.

The experiment was carried out in the following manner on 15th Sept.; separated the egg-sacs from the body of worm which was previously picked out by means of pincette; put each of four pairs into 10 glass-cups contained 400 c.cm. of water; placed the cups in the thermostat,* which was regulated to maintain the constant

* Seno, H. & Tauti, M.: Apparatus for maintaining a series of constant temperatures. (Journ. Imp. Fish. Institute. Vol. 20, No. 4, 1924).

temperature, ranging from 10.1° to 39.6°C. ; microscopically examined them every day and determined the rate of the hatching ; left the hatched larvae in the cups and observed the further development. Each of the egg-sacs used was 3–4 mm. long and contained about 250–300 eggs of 0.12–0.14 mm. in the diameter.

The experiment lasted till Oct. 4, 1926 and showed the following data :

TABLE II. The hatching results.

No. of lot.	No. 1	2	3	4	5	6	7	8	9	10
Mean water temperature.	39.6°C.	36.5	33.2	29.8	25.9	22.9	20.4	17.7	14.0	10.1
Mean variation of water temperature.	0.5°C.	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.8
Number of egg-sacs used.	8	8	8	8	8	8	8	8	8	8
Number of egg-sacs hatched.	—	—	?	7.3	7.0	7.0	4.2	2.2	1.6	—
Percentage of hatching.	—	—	?	91%	88	88	53	28	20	—
Mean hatching days.	—	—	?	1.0	1.3	1.7	2.1	2.8	7.0	—
Survived days of nauplius or metanauplius.	—	—	2	2	3	3	6	8	17	—
Survived days of 1st or 2nd copepodid.	—	—	2	4	4	8	6	8	—	—

Remarks: In No. 1–2 and No. 10, no larvae hatched out; an extremely poor result in the hatching was obtained from No. 3, but the egg-sacs being collapsed, the percentage could not be determined. The larvae hatched in No. 9 showed no further development beyond the metanauplius. No more advanced stage than the 2nd copepodid was observed in this experiment. The surviving days don't signify such exact days as measured throughout by the same larvae, but indicate the number of days from the first appearance to the last.

It is feared that the percentage and the days of the hatching might have missed the mark, for unsatisfactory quantity of egg-sacs, in which the eggs developed diversely, were used. But the extent of the degree of the favourable temperature for the hatching of eggs may be explained as follows: The eggs in No. 1–2 and 10 died out without hatching, and a very few larvae were obtained from No. 3. Contrary to the former, the results of the lots No. 4–6 were favourable, which resembled so very closely with each other that the optimum among them could hardly be determined. The eggs in No. 7 hatched out with lower percentage, but those in No. 8–9 showed far poorer

TABLE III. Detailed list of the hatching.

Lot / Date	No. 1	2	3	4	5	6	7	8	9	10
Sept. 15	4 pairs of egg-sacs used.	,,	,,	,,	,,	,,	,,	,,	,,	,,
16	All died out. Egg-sacs collapsed.	Most of egg-sacs collapsed and died.	A few hatched, others died out.	3⅞ pairs of egg-sacs hatched.	2½ pairs of egg-sacs hatched.	1 pair of egg-sacs hatched.	1 pair of egg-sacs hatched.	1/10 pair hatched. 2 pairs died.	No hatching.	No hatching.
17		The rest died out.	Metanauplius.	The rest died out. Metanauplius.	1 pair hatched.	1½ pairs hatched.	½ pair hatched, 1 pair died.	Nauplius.	,,	,,
18			1st Copepodid.	1st Copepodid.	Metanauplius.	Metanauplius.	Nauplius,	1 pair hatched. The rest died out.	1/10 pair hatched.	,,
19			Died out in the same stage.	,,	The rest of egg-sacs died out. 1st copepodid.	The rest of egg-sacs died out.	½ pair hatched. Metanauplius.	Nauplius.	Nauplius.	Egg-sacs somewhat opaque.
20				Most larvae died in the same stage.	1st copepodid.	1st copepodid.	1/10 pair hatched.	Metanauplius.	2/5 pair hatched. 2 pairs died.	,,
21				The rest died out in the same stage.	Most larvae died in the same stage,	,,	The rest of egg-sacs died out.	,,	Nauplius.	2 pairs died.
22					The rest died out in the same stage.	,,	Metanauplius, 1st copepodid.	,,	,,	Egg-sacs opaque.
23						,,	1st copepodid.	,,	,,	,,
24						,,	,,	1st copepodid.	Metanauplius.	,,
25						,,	Most larvae died in the same stage.	,,	,,	1½ pairs died.
26						Died out in the same stage.	2nd copepodid.	2nd copepodid.	3/10 pair hatched.	The rest of egg-sacs died out.
27							Died out in the same stage.	,,	The rest of egg-sacs died out.	
28								,,	Nauplius and metanauplius.	
29								,,	,,	
30								Most larvae died in the same stage.	,,	
Oct. 1								The rest died out.	Most metanauplii died.	
2									Metanauplius.	
3									,,	
4									The rest died out in the same stage.	

results. Accordingly it may be infered that the favourable water temperature for the hatching of eggs may be represented by Lots No. 4–7, being approximately from 20°–30°C., and this limit nearly corresponds to the water temperature during the dangerous season of this disease as already described.

TABLE IV. The seasonal variation of the water temperature at one of the fish cultural ponds in middle Japan.

Month	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Water temper.	4.3°C.	5.8	8.6	14.1	19.9	23.1	26.5	27.5	23.1	17.6	12.0	7.1

Remarks: This is the monthly average of the recent four years' statistics, 1923–26, which were taken at the Shiga Fish Cultural Station on the coast of Lake Biwa.

The hatched larvae in No. 3–8 metamorphosed into the 1st or 2nd copepodid stage in the free swimming state, but showing no further development they died out within 3–15 days, and none in No. 9 developed beyond the metanauplius, though it survived 17 days long. Thus, there is a marked difference in the rate of development of early larvae according to the gradient of the water temperature, but the further influence upon the later copepodid larvae could not be determined, owing to the fact that the larvae came to the end in the 1st or 2nd copepodid unless they infested on sufficient hosts. This is significant on the parasitism and was also recognised by Wilson in his study of *Lernaea variabilis*: "If there is nothing present to which they can fasten they swimm about until tired..... . They can be kept alive in this way for several days." (6, pp. 168) While on the gills of the gars, the temporary host, examined from Aug. 15 to Oct. 4, 1915 "each copepodid stage occuppies from 10 to 14 days....." (6, pp. 190) On the other hand Lebour (3, pp. 9) described after the artificial rearing of the free swimming species, *Calanus finmarchius* (Gunuerus), as follows: "Nauplii first appeared between the 17th and 24th of April, and on May 19th Stage V was taken from the jar, having taken certainly less than two months to grow from the egg to this stage." But in both cases the measurement of the water temperature being neglected, I can not exactly see the influence of the water temperature on the later copepodid larvae.

In short, the favourable temperature for the hatching of eggs may be approximately 20°–30°C., in which the hatched larvae may metamorphose into the 1st or 2nd copepodid within 6–12 days but no further development is to be expected unless they infest

on the suitable host, and this limit nearly corresponds to the water temperature during the dangerous season of this disease. In the temperature of higher than 36.5°C. and lower than 10.1°C., the eggs come to the end without hatching and none developed beyond the metanauplius in the temperature of 14.0°C.

The experiments of the artificial infection.

Two series of examination were made out in this experiment; namely, the artificially hatched larvae were, in the first place, examined on *Oryzias latipes* in the thermostat, and then the later copepodid from the diseased carps were infected on the gold fish and *Oryzias latipes*.

On Sept. 21, the 1st copepodid larvae of 5 days old after the hatching were put into the glass cup contained about 400 c.cm. of water and then liberating 3 trial fishes, the reservior was placed in Lot No. 6 of the thermostat. (22.9°C.) On the next day there was left no larva swimming about and many small white dots like those of the ichthyophthiriasis were observed on the fins of each fish, but killing one of the fishes in formalin, the larvae were separated from the fish again. Thus, the fish being proved to be infested with parasites, the water in the cup was carefully renewed every day hereafter. But the trial fishes unfortunately died on Sept. 27 and Oct. 1 respectively and showed no sign of infection either on the skin or on the gills and even the white dots on the fins were already disappeared. On Sept. 27 another examination was tried in the same manner as in the former, taking the 2nd copepodid larvae of 11 days old after the hatching and placing the cup in Lot No. 7 (20.4°C.) of the thermostat. The development was very similar to the first experiment and each fish having no parasite remained on the surface of body died on the 4th, 7th and 10th of October respectively. Thus the trial fishes being perished in both cases, the present experiment had been suspended and I could not precisely decide whether it might be to the incompleteness of the experimental method or might be caused by the habitual characteristic of the present species.

The other examination in which the later copepodid larvae were used, was carried out as follows: On Sept. 15 the diseased carps, heavily infested with adult worms, were put into the aquarium (84 cm. long, 46 cm. wide and 60 cm. deep) and on the next day they were replaced with two gold fishes. Soon after the liberation the latter swam about in an uneasy manner, making a heavy motion of the mouth parts like that of coughing, but becoming gradually tired they rested themselves on the bottom. In 5 hours many filamentous young females were already observed on the various parts

of the fish, projecting about 1 mm. from the surface of the body. Two days afterwards one fish died, which was infested with the parasites of about 6 mm. in the body length (without the anal setae). (Figs. 58–60, Pl. IV) The worms parasited on the other fish caused the heavy congestion on the affected parts and daily grew bigger. On the 5th day after the infection they bore the egg-sacs of about 1–2 mm. long; but the host died on the next day, no further development could be observed. The parasites crowded on the fish, as shown on the Textfig. 4, extending until the body length of about 7–8 mm., construction of which resembled very much to that of the adult females. (Fig. 61, Pl. IV)

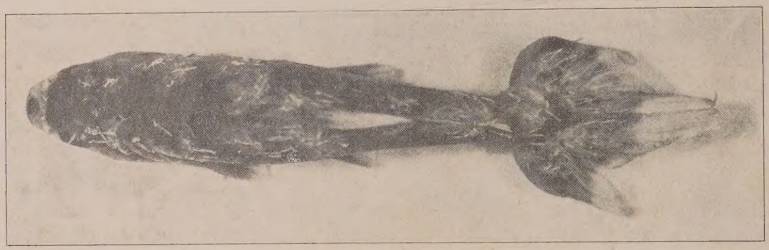

Fig. 4. The young females infested on the gold fish 5th days after the infection. × ca. $\frac{5}{7}$

At the end of this experiment the aquarium was drained off and filtering the water through the plankton-net many later copepodid larvae were obtained. Hereupon filling the water into the aquarium and putting the larvae in it again, 3 of *Oryzias latipes* were liberated on Sept. 23. On the next day the thread like young females which projected about 1 mm. appeared on each fish. Two days afterwards one fish died which was infested with 14 parasites of 4–6 mm. in the body length, and somewhat greater worms bearing the egg-sacs of about 1–2 mm. were obtained from another fish which was lost on Oct. 3, but the parasites on the rest of the fish became mouldy by this time and without giving a fatal disease on the host, they were entirely fallen off until Oct. 5. Later, in spite of the liberation of 20 fishes of the same species on Oct. 1, none was infested in 6 days and no more larva was able to detect in the aquarium.

In short, though I failed in the artificial infection of the early larvae, I am much inclined to believe the necessity of such temporary host as Wilson states in the course of their development. Further it is very worthy of note that the later copepodid worm has made the rapid growth, metamorphosing into the thread like young females within 5 hours and becoming the mature ones in 5–8 days; and the latter was measured 7–8 mm. in the body length and bore the egg-sacs of about 1–2 mm. long. It is, however, a regretable thing that the measurement of the water temperature was neglected in this experiment.

The life history.

The materials for this experiment were collected as follows ; the nauplii, metanauplii and 1st copepodid larvae were hatched artificially, the 2nd to 5th copepodid infested on the diseased carps and the young as well as the adult females were taken from the gold fishes which were artificially infested. As this work chiefly consisted in the morphological study, the materials were mostly examined in the fresh or in formalin hardened condition but they were often prepared in the total preparate stained with borax carmine and clarified with clove oil.

The nauplius. (Figs. 1–4, Pl. II)

The newly hatched larvae are an elliptical form of 0.15 mm. long and 0.10 mm. wide in the average measurement. The body, without eye, is transparent and light greenish uniform colour excepting the dark digestive tract. The 1st antennae uniramose, with two joints; the basal segment, longer than the terminal, has one seta and one spine at its distal end, and the second one tipped with 2 plumose setae and 2 or 3 spines. The 2nd antennae biramose ; the exopode consists in 4 segments, the first one the biggest, the second and third ones broad and the fourth one more or less slender. On each inner margine of the 1st—3rd joint arises one long plumose seta and the 4th segment tipped with one long plumose seta and 2 small spines. The endopode with one joint, has 2 long plumose setae at the tip and 1 small spine on the inner margin. The mandibles, smaller than the second antennae, have similar construction but they want the spine on the terminal joint of the exopode and on the inner margin of the endopode. At the posterior margin of the body, two long and stout spines are situated closely together on the midline.

Comparing this construction to that of Wilson's *Lernaea variabilis*, there is much likeness between the two excepting the following differences : The basal segment of the first antennae tipped with one seta and one spine in this species, while none in the other, and this has one more nonplumose seta on the terminal segment ; the present species has two more small spines on the terminal joint of the exopodes of the 2nd antennae, and the endopodes of the 2nd antennae and the mandibles consist in one segment in this species but they are two joints in the other.

The metanauplius. (Figs. 5–9, Pl. II)

The transparent body, without pigment, and somewhat elongated oviform of 0.16 mm. long and 0.10 mm. wide but more or less flattened on the ventral side.

The two compound eyes are closely situated on the midline of the anterior dorsal side of the body. At the posterior part of the body appears a pair of the anal laminae which bears 3 anal setae, the inner one the longest and the outer two rather contiguous, and a pair of a small spines projects on the base of the anal laminae. The terminal joint of the 1st antennae armed with 4 or 5 more spines than the nauplius, the endopode of the 2nd antennae, with 1 long plumose seta and 3 small spines, and the rudiment of the 1st maxillae tipped with 2 spines, appears. In other respects it is quite the same construction as in the former stage.

In comparison with Wilson's description the following differences are observed: The basal joint of the 1st antennae armed with 1 plumose seta and 1 long spine, and the terminal one tipped with 2 plumose setae and 2 less spines than in *Lernaea variabilis;* the endopode of the 2nd antennae and the mandibles with one joint; the terminal segment of the exopode of the 2nd antennae are armed with 2 more small spines; and no large spine presents on the dorsal surface of the body.

A moderate change in the shape of body which may be accompanied by each molt, is observed in the course of development, and the lower the water temperature, the more the difference of form is distinctly seen.

The most advanced metanauplius, so far as I saw, was rarely found among the later copepodid larvae which had been gathered from the aquarium in the foregoing experiment. It is illustrated in Textfig. 5 and attained 0.24 mm. in the body length and 0.15 mm. in width. At the posterior part of the body, a pair of the anal laminae projects which armed with 2 large anal setae and 3 very small spines. The 1st antennae with 3 joints, the first segment without spine, the second one armed with 1 plumose seta and 2 spines and the third one with 2 plumose setae and 1 small spine at the tip and 3 spines at the inner margin. The coxopode of the 2nd antennae tipped with 2 well developed thorns and the basipode with 1 small thorn; the endopode with 2 joints, the basal joint without spine and the terminal one bears 4 plumose setae; the exopode with 4 joints, each of the first to third segment tipped with 1 plumose seta and the terminal one with 2 plumose setae. The coxopode of the mandibles unarmed, the basipode has 1 thorn; the basal joint of the endopode armed with 3 small spines on the inner margin but the terminal segment and the exopode are constructed as same as the 2nd antennae. As to the other construction it was unable to explain, owing to the incompletness of the material.

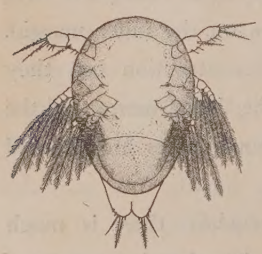

Fig. 5. The later metanauplius. × ca. 120.

The 1st copepodid larva. (Figs. 10–14, Pl. II)

The body, transparent with light yellowish uniform colour excepting the dark digestive canal, is measured 0.47 mm. in the total length (including the anal setae) and 0.29 mm. in the body length. On the anterior dorsal side of body two compound eyes are closely situated on the midline. The cephalothorax, 0.14 mm. long and 0.12 mm. wide, is elliptical shape and the 3 following segments diminish gradually in width and finally comes a rectangular abdominal segment which bears two anal laminae at the distal margin. The 1st and 2nd antennae are nearly the same size, with 2 joints and the basal segment is about one and half times as long as the terminal ones. The basal joint of the 1st antennae armed with one plumose seta and 2 spines and the distal one with 3 plumose setae and 5 or 6 spines, while in the 2nd antennae the basal segment unarmed and the terminal one tipped with one strong prehensible claw and 3 blade bristles at distal end and 2 small spines at inner margin. As the constructions of the mandibles, maxillae and maxillipeds are nearly the same in each copepodid stage, so the detailed descriptions are to be given together on the later part of this work. Two pairs of the swimming legs are found. Each of them biramose with a joint, arises on a large broad coxopode and a short wide basipode. The endpode of the 1st swimming legs armed with one plumose seta at inner margin, 4 plumose setae on the tip and 2 thorns at outside; the exopode with 4 plumose setae at the distal end and 4 thorns at outer margin. The both laminae of the 2nd swimming legs tipped with one less plumose seta than the first one. At the distal corner of the third thoraxic segment (the free second one) appears a pair of the rudiment of the third swimming legs tipped with two small spines. Each anal lamina bears a very long inner seta and 4 of much shorter outer spines.

The 2nd copepodid larva. (Figs. 15–23, Pl. II)

A new free thoraxic segment is added but the abdominal one remains unchanged. Three pairs of the swimming legs are seen, of which the first two become two jointed, while the third consists in a pair of a single lamina, and besides the rudiment of the fourth swimming legs appears on the distal corner of the new fourth thoraxic segment.

The total length, 0.53 mm.; the body length, 0.36 mm. The cephalothorax, 0.17 mm. long and 0.14 mm. wide, becomes more or less roundish at its frontal margin. The 1st and 2nd antennae remain still unchanged, but occasionally with 3 joints. The 1st antennae are usually armed with a plumose seta and 5 spines on the basal segment,

and 2 plumose setae and 6 spines on the distal one; while in the three jointed pair, the first segment tipped with 6 spines, the second one with a plumose seta and 4 spines and the third with 2 plumose setae and 6 spines. But the 2nd antennae, whether they may be two or three jointed, has the same construction as in the former stage or with one more blade bristle. The basipode of the 1st swimming legs bears a spine at outside and a spine and a strong claw on the inner margin; the first joint of the endopode armed with a plumose seta and the second one with 4 or 5 plumose setae and 2 thorns; the basal joint of the exopode bears a plumose seta and a thorn, and the terminal one with 5 plumose setae and 3 thorns. The basipode of the 2nd swimming legs with or without a spine at outer margin; the endopode as same as the 1st swimming legs; the basal joint of the exopode is also the same construction as that of the 1st swimming legs but it is often wanting a plumose seta inside; the terminal joint armed with 4 or 5 plumose setae and 2 or 3 shorter and one longer thorns. The endo- and exo-pode of the 3rd swimming legs, consisting in a single lamina, has 3 or 4 plumose setae and 2 or 3 thorns, and the rudiment of the 4th swimming legs tipped with 2 spines.

The 3rd copepodid larva. (Figs. 24–31, Pl. II–III)

Total length, 0.69 mm; body length, 0.45 mm. The genital segment is added to the 4 free thoraxic segments, but the abdominal one, though increased in size, still remains entirely fused. A pair of the 4th swimming legs and the rudiment of the 5th ones come in sight. The 1st and 2nd antennae with 4 and 3 joints respectively; the 1st to 3rd swimming legs are still two jointed but 4th one consists in a pair of a single lamina.

The cephalothorax, 0.19 mm. long and 0.17 mm. wide. In the 1st antennae, the first joint with 2 or 3 spines, the second one 3 or 4, the third one 4 or 5 and a plumose seta, and the fourth one 6 or 7 and 2 plumose setae; while in the 2nd antennae, no spine presents on the first and second joints but the terminal one tipped with a strong claw and 4 blade bristles, and with 2 or 3 small spines inside. In the 1st and 2nd swimming legs, the first segment of the endopode armed with a plumose seta and the second one 5 plumose setae and 2 thorns; the basal joint of the exopode with a plumose seta and a thorn, and the terminal one with 4 or 5 plumose setae and 3 or 4 thorns. The 3rd swimming legs have much the same construction as that of the 1st. ones but wanting a thorn on the terminal joint of the endopode and a plumose seta on the basal segment of the exopode. The 4th swimming legs bear 4 plumose setae and 2 thorns on the endopode, and 3 plumose setae and 3 thorns on the exopode.

The rudiment of the 5th swimming legs consisting in a pair of papillae tipped with 2 spines, appears at the posterior corner of the fifth thoraxic segment.

Thus, the present larva has just the intermediate construction between Wilson's second and third copepodid larvae, of which the latter are, as he states, of a different species taken from the different host, while my examples of the same species were 6% which were parasited on the diseased carps. According to Wilson, he divides the development of the genus Lernaea into four stages, but by the free swimming copepods Brehm (1, pp. 458) has recently compiled as follows: "Die durch Dietrich vertretene Anschaung wird von neueren Autoren bestritten, denen zufolge beide Gruppen freilebender Copepoden 2 Orthonauplien, 4 Metanauplien und 6 Copepodidstadien durchlaufen." Assuming, in consequence, it is advisable to establish a stage of the present larva distinctly, I should have to place it between Wilson's second and third copepodid stages and to divide the development of the copepodid larvae into 5 divisions.

The 4th copepodid larva. (Figs. 32–40, Pl. III)

This corresponds to Wilson's third copepodid larva. The total length, 0.83 mm; body length, 0.56 mm. The abdomen separates into two segments. The 4th swimming legs have 2 joints and the rudiments of the 6th swimming legs appear at the distal corner of the genital segment but they are often wanting.

The cephalothorax, 0.23 mm. long and 0.19 mm. wide. The 1st and 2nd antennae are as same as the former stage but the spines on the 1st antennae are more or less increased in number. In the 1st swimming legs, the endopode armed with a plumose seta on the basal joint, and 5 plumose setae and 2 thorns on the terminal one; the exopode with a plumose seta and 1 or 2 thorns on the 1st segment, and 5 plumose setae and 2 or 3 thorns on the second one. The 2nd and 3rd swimming legs have nearly the same construction as those of the former ones but the terminal joints of the exopodes of both pairs armed with one more thorn, and the terminal one of the endopode of the second legs often tipped with 6 plumose setae. The 4th swimming legs have one less plumose seta than the 2nd pairs on the terminal joint of the endopode and on the basal segment of the exopode and the 5th legs which bear a broad basipode armed with a spine at outer margin, are uniramose lamina tipped with 3 nonplumose setae. The rudiments of the 6th legs consist in a pair of papillae tipped with 2 spines but they are often wanting. This fact may, perhaps, be regarded as one of the sexual dimorphism, i.e., the one which bears the rudiment of 6th swimming legs, may grow up to

be a male and the other a female; because such a relation can be observed in both sexes in the following stage.

The 5th copepodid larva. (Figs. 41–57, Pl. III–IV)

This larva, which corresponds to Wilson's 4th stage, occupies the greater part of those infested on the diseased carps. The abdomen being newly added one segment, is divided into 3 parts, and the genital segment takes rapid growth. The biramose laminae of the 1st to 4th swimming legs with 3 joints, but the 5th and 6th ones remain unchanged. A distinct sexual differentiation arises and the mating takes place during this period. As to the proportion of both sexes Wilson describes (6, pp. 190): "During the several copepodid stages and for some times subsequently two sexes are found in about equal numbers. Then the proportion of female diminishes steadily and by the end of September only an occasional female is left, while the males are apparently undiminished." Against this, I have obtained the ratio of 1 ♀: 3 ♂, detecting 17% of female and 50% of male on the diseased carps, and many females are still left in this case. But this may be the seasonal differentiation, because examples were collected in mid September.

The male larva.

The total length, 1.10 mm.; the body length, 0.71 mm. The cephalothorax is 0.26 mm. long and 0.23 mm. wide. The 2nd thoraxic segment (the 1st free one) is as wide as the cephalothorax but the following three segments diminish rapidly in width. The genital segment well developed but more slender than that of the female. There are now three abdominal segments of which the terminal one bears two jointed anal laminae. The anterior extremity of the cephalothorax forms a pair of rostra which strongly curves inwards. The compound eyes and a shallow groove which may be the fused line of the cephalon and the thoraxic segment appear on the anterior dorsal surface of the cephalothorax. The basal joint of the anal lamina is unarmed but the terminal one tipped with a long plumose seta and 3 spines, and besides 2 very small spines are newly added at the base of the long seta. The 1st antennae with 4 joints, each armed with more spines than those of the female, and the second segment tipped with a plumose seta, and the fourth one with 2 plumose setae. The 2nd antennae with 3 joints, the first two segments without spine, the distal one armed with a strong prehensible claw and 5 blade bristles at the tip and 3 small spines at inside. The mandibles could not be made out clearly by the previous removal of the maxillae, but in the total preparates clarified with clove oil, they are occasionally observed in the mouth

tube. They are styli-form as Leigh-Sharpe states and are probably one jointed without teeth. The 1st maxillae consist of a pair of broad single joint tipped with strong claws. They are covered with the 2nd maxillae, so that they are difficully found on the ventral view but are distinctly observed at the lateral side. The 2nd maxillae greater than the 1st one, are attached to the outside of the mouth tube and converge inwards at the mouth part. Each of them is made of a stout basal joint and two terminal claws which meet on the median line. A pair of maxillipeds project at some distance from the mouth tube and each is constructed with a large stout basal joint and the terminal one. The basal segment has a small papilla tipped with a spine, at its inner distal margin and the terminal one with 5 well developed prehensible claws. Between the basal part of the maxillipeds appears a small round chitinous ridge (chr. in Textfig. 6), which may correspond to what Leigh-Sharpe considered as a single median aperture, but concerning its function it is to be determined after the histological research. A pair of strong thorns (th. in Textfig. 6) arises at the outer margin between the basal parts of the maxillipeds and the 1st swimming legs, but I could not find such thoraxic legs as Leigh-Sharpe describes and figures. Each of the 1st to 4th swimming legs are situated on a broad coxopode and a short wide basipode. In the 1st swimming legs, the coxopode armed with a spine and the basipode with a strong claw and a spine; each of the 1st and 2nd joint of the endopode bears a plumose seta and the terminal one tipped with 5 plumose setae and 2 thorns; the exopode has much the same construction as in the former but the 1st and 2nd joint has respectively one more thorn than that of the endopode. In the 2nd swimming legs, the coxopode and basipode has a spine respectively; the 1st joint of the endopode and the 1st and 2nd ones of the exopode are as same as the first pair, but in the endopode the 2nd segment armed with 2 plumose setae and the terminal one with 3 plumose setae and 3 thorns; the 3rd joint of the exopode bears one more thorn than those of the 1st pair. The 3rd and 4th swimming legs have quite the same construction as in the 2nd pair, but in the 4th one a plumose seta is occasionally wanting at the terminal joint of the endopode. The 5th pair uniramose, consists in a broad basipode tipped with a spine and the terminal lamina armed with 6 nonplumose setae. The rudiments of the 6th swimming legs arise at the posterior corner of the genital segment, consisting in a pair of small papillae tipped with 2 spines.

Fig. 6. Ventral view of a part of the cephalothorax. × ca. 100.

The genital organs are clearly observed in the total preparates, stained with borax

carmine and clarified with clove oil. A pair of testis, spindel shaped and more or less dorso-ventrally flattened, are situated between the posterior part of the cephalothorax and the 2nd or 3rd thoraxic segment. They are not an equal size and are obliquely placed on the dorsal surface of the digestive tract. From the anterior end of the testis the sperm ducts run back alongside the intestine to the 3rd thoraxic segment and then taking oblique course to the ventral side reach the genital segment where they terminate into the enlarged ellipsoidal spermatophore receptacles.

The female larva.

They are greater but more or less slender than the males. The total length, 1.29 mm ; the body length, 0.89 mm ; and the cephalothorax, 0.31 mm. long and 0.26 mm. wide. The appendages have much the same construction as those of the male but differ in the following points ; on the 1st antennae, the spines are less in number than those of the male ; the 5th swimming legs tipped with 4 spines ; the rudiment of the 6th swimming legs is wanting ; the 2nd antennae and the maxillipeds are more or less slender than those of the male.

The genital segment is stouter than the male, has a pair of prominences in which the vulva dehisces, on the ventral side. A pair of spermatophore receptacles are frequently attached to the genital segment, but two pairs of them are seldom found. In the size, shape and situation, the ovary resembles greatly to the testis. From the anterior end of the ovary, the oviduct leads back to the vulva, but its posterior portion does not yet make the cement gland. But the female reproductive organs show, on the whole, inferior results in staining, so that they can not be clearly illustrated.

The young female. (Figs. 58–65, Pl. IV)

After the mating, the thoraxic segments of the female larvae may be elongated before they begin to burrow the host. (Textfig. 7.)

As already mentioned, the young females make a rapid growth, attaining about 3 mm. in the body length within 5 hours after the prehension to the host, and in 5 or 8 days they become the mature worms which are measured 7 to 8 mm. in the body length and bear the egg-sacs of about 1 to 2 mm. long.

In the young females which are measured about 3 mm. in the body length, the elongation of the body is chiefly caused by the strech and union of each thoraxic segment, while the cephalothorax and the abdomen remain almost unchanged. The appendages which are constructed as same as the latest copepodid stage, show no tortional arrangement being situated on the same plane. The ovary spindle shaped

and posteriorly pointed out, migrate from the anterior part of the body to the 4th and 5th thoraxic segments and is situated side by side on the dorsal surface of the intestine.

Fig. 7. The female larva, showing the elongation of the thoraxic segments. × ca. 30

From the anterior extremity of the ovary the oviduct leads back to the vulva alongside the intestine and the posterior half becoming thick and glandular, forms the cement gland, yet no egg is contained.

In the specimens of about 6 to 7 mm. in the body length, a series of eggs are contained in the oviduct which is much lengthened and convoluted, but no eggs-sacs presented.

Within 5 to 8 days after the prehension, the worm may attain to nearly full grown size, then the egg-sacs and the rudiments of the cephalic horns appear at last. The club-shaped dorsal horns come out at the posterior corner of the cephalothorax at first and then the conical ventral horns project at some distance forwards to the former ones. By this time the cephalothorax being increased at its posterior margin, it becomes triangular form, and far later on the rudiments of the lateral branches of the dorsal horns appear.

The thoraxic appendage and the auricular expansion of the head which are taken by Leigh-Sharpe as the specific characters of the present species, are not also present in the young as well as the mature females.

Summary.

1. The favourable water temperature for the hatching of eggs of *Lernaea elegans* may be approximately 20°–30°C., which nearly correspond to the natural water temperature during the invasion period of the present disease.

2. In the water temperature of 17.7°–33.2°C., the hatched larvae metamorphose into the first or second copepodid stage within 4 to 16 days, but no further development is to be expected unless the sufficient host is to be given.

3. In the water temperature of 14.0°C., the hatched larvae come to the end within 18 days showing no further development beyond the metanauplius.

4. No hatching takes place in the water temperature of more than 36.5°C. or less than 10.0°C.

5. In the mucous of the skin of the diseased carps, the copepodid larvae infest in the following percentage:

1st copepodid	2nd copepodid	3rd copepodid	4th copepodid	5th copepodid		Total number, examined.
				♂	♀	
1 %	6 %	6 %	20 %	50 %	17 %	852

6. On infecting the 5th copepodid larvae upon the gold fish and *Oryzias latipes*, the young females of about 6 mm. long (without the anal setae) are obtained within 2 or 3 days and they grow up nearly to adult worms in 5 or 8 days, attaining about 7–8 mm. in the body length and bearing the egg-sacs of about 1 to 2 mm. long.

7. The experimental infection of the artificially hatched larvae (1st or 2nd copepodid) on *Oryzias latipes* has been suspended, owing to the death of the fishes for examination within 6–13 days, and by this time no larva metamorphoses into the young female.

8. Though the present species seems to require also the temporary host for the copepodid larvae as Wilson describes, yet it is to be decided on another day.

9. The development of this species almost agrees with that of *Lernaea variabilis*, but the 3rd copepodid larva of the former having the intermediate construction between the 2nd and 3rd ones of the latter, is recognized as a distinct stage and in consequence the development of the copepodid larvae is divided into five divisions.

10. The young female of about 3–4 mm. in the body length shows no tortional arrangement of the swimming legs and has no rudiment of the cephalic horns ; though the ovary migrates towards the posterior part of the trunk, yet no egg is contained in the oviduct which is still slender and simple.

11. In the female of about 7.5 mm. in the body length, the rudiments of the cephalic horns appear on the posterior corner of the cephalothorax ; namely the club-shaped dorsal horns come at first in sight, then the conical ventral ones and finally protrude the lateral branches of the dorsal horns. The oviducts with uniseriate eggs are convoluted and the posterior half becoming thick and glandular form the cement gland. A pair of egg-sacs of about 1 to 2 mm. long appears.

12. The thoraxic appendage and the lateral auricular expansion of the head which are described by Leigh-Sharpe as the characteristics of the present species, are not observed in the copepodid larvae as well as in the females.

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2. Ishii, S.: Lernaeocera infesting on the crucian carp. (Journ. of Zoology. Vol. 27, No. 322, 1915. Tokyo. in Japanese)
3. Lebour, M.: Stage in the life history of *Calanus finmarchius* (Gunuerus), experimentally reared by Mr. L. R. Crawshay in the Plymouth laboratory. (Journ. of Marine Biological Association. Vol. 11, 1916–18)
4. Leigh-Sharpe, W.: *Lernaea elegans* n. sp., a parasitic copepod of *Anguilla japonica*. (Parasitology. Vol. 17, No. 3, 1925)
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6. "——": The economic relations, anatomy and life history of the genus Lernaea. (Bullet. of the Bureau of Fisheries, U.S.A. Vol. 35, 1918)

The explanation of the figures. (Figs. 1–65, Pl. II–IV)

Plate II.

Nauplius: Fig. 1, dorsal view; fig. 2, 1st antenna; fig. 3, 2nd antenna; fig. 4, mandible. (Fig. 1, × 140; figs. 2–4, × 300)

Metanauplius: Fig. 5, ventral view; fig. 6, side view; fig. 7, 1st antenna; fig 8, 2nd antenna; fig. 9, anal lamina. (Figs. 5–6, × 140; figs. 7–9, × 300)

1st copepodid larva: Fig. 10, ventral view; fig. 11, 1st antenna; fig. 12, 2nd antenna; fig. 13, 1st swimming leg; fig. 14, 2nd swimming leg. (Fig. 10, × 100; figs. 11–14, × 300)

2nd copepodid larva: Fig. 15, ventral view; fig. 16, 1st antenna; fig. 17, 2nd antenna; fig. 18, 1st antenna with 3 joints; fig. 19, 2nd antenna with 3 joints; fig. 20, 1st swimming leg; fig. 21, 2nd swimming leg; fig. 22, 3rd swimming leg; fig. 23, 4th swimming leg. (Fig. 15, × 100; figs. 16–23, × 300)

3rd copepodid larva: Fig. 24, 1st swimming leg. × 300

Plate III.

3rd copepodid larva: Fig. 25, dorsal view; fig. 26, 1st antenna; fig. 27, 2nd antenna; fig. 28, 2nd swimming leg; fig. 29, 3rd swimming leg; fig. 30,

4th swimming leg; fig. 31, rudiment of 5th swimming leg. (Fig. 25, × ca. 80; figs. 26–31, × 300)

4th copepodid larva: Fig. 32, dorsal view; fig. 33, 1st antenna; fig. 34, 2nd antenna; fig. 35, 1st swimming leg; fig. 36, 2nd swimming leg; fig. 37, 3rd swimming leg; fig. 38, 4th swimming leg; fig. 39, rudiment of 5th swimming leg; fig. 40, rudiment of 6th swimming leg. (Fig. 32, × ca. 80; figs. 33–38, × 300; figs. 39–40 × 150)

5th copepodid larva: Fig. 41, 1st antenna of male; fig. 42, 2nd antenna of male; fig. 43, maxilliped of male; fig. 44, anal lamina of male; fig. 45, 1st antenna of female; fig. 46, 2nd antenna of female; fig. 47, maxilliped of female. (Figs. 41–43, × 150; fig. 44, × 200; figs. 45–47, × 150)

Plate IV.

5th copepodid larva: Fig. 48, dorsal view of male; fig. 49, ventral view of anterior part of cephalothorax of male; fig. 50, 1st swimming leg of male; fig. 51, 2nd swimming leg of male; fig. 52, 3rd swimming leg of male; fig. 53, 4th swimming leg of male; fig. 54, 5–6th swimming leg of male and spermatophore receptacle; fig. 55, dorsal view of male reproductive organs; fig. 56, ventral view of female; fig. 57, 5th swimming leg of female and genital segment. (Fig. 48, × 50; figs. 49–54, × 200; fig. 55, × ca. 75; fig. 56, × ca. 35; fig. 57, × 150)

Young female: Fig. 58, ventral view of young female of 2 days old after the prehension; fig. 59, ditto, anterior part of body; fig. 60, ditto, genital segment; fig. 61, cephalothorax of young female of 5 days old after the prehension; fig. 62, cephalothorax of young female of 7 days old after the prehension; fig. 63, ditto, genital organs with no egg in the oviduct; fig. 64, ditto, genital organs with eggs in the oviduct; fig. 65, cephalic horns of adult female. (Fig. 58, × ca. 15; fig. 59, × ca. 50; fig. 60, × 100; fig. 61, × 50; fig. 62, × ca. 10; fig. 64, × ca. 23; fig. 65, × ca. 8)

Lettering in figures.

ab, abdomen; ab′, ab″, ab‴, 1st to 3rd abdominal segment; al, anal lamina; al′, al″, basal and terminal segment of anal lamina; an′, an″, 1st and 2nd antenna; ans, anal seta; bdh, branch of dorsal horn; bl, blancer; c, cephalon; cg, cement gland; cth, cephalothorax; dh, dorsal horn; enp, endopode; exp, exopode; gpr, genital pro-

minence; gs, genital segment; int, intestin; md, mandible; mx′, mx″, 1st and 2nd maxillae; mxp, maxilliped; o, egg; od, oviduct; ov, ovary; r, rostrum; 1sl, 2sl..... 6sl, 1st, 2nd.....6th swimming leg; spd, sperm duct; sph, spermatophore; spr, spermatophore receptacle; tes, testis; v, vulva; vh, ventral horn.

ON THE OPTIMUM TEMPERATURE OF WATER FOR HATCHING THE EGGS OF RAINBOW TROUT (*Salmo irideus* GIBBONS).

By

Minoru Kawajiri.

In a previous paper[1], I reported on the optimum temperature of water for hatching the eggs of *Oncorhynchus masou* Brevoort.

In the present study, I made an experiment on the optimum temperature of water for hatching the eggs of rainbow trout (*Salmo irideus* Gibbons), from Apr. 8th to July 29th, 1927.

The parent fishes used for this experiment were caught in a pond at Kizaki Fish-cultural Station Imp. Fish. Inst.; Prefecture Nagano. The ripened eggs and sperm taken from them were artificially fertilized by dry method. After washing away the excess of sperm, every 20 eggs was transferred to each cup filled with about 100 c.c. of water. Then the cups were placed one by one into 10 different dark chambers of the thermostat[2] which was regulated to maintain a series of constant temperatures between 16.9°～3.1°C. The water in cups was very cautiously changed by a siphon with the water of the same temperature as that in each cup.

Besides the 10 cups in the thermostat, I prepared another sample for the control, which was placed in a hatchery supplied with running water.

The results of the present experiment are given in Tables I and II.

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1) Jour. Imp. Fish. Inst. Vol. XXIII, No. 2, 1927.

2) Seno, H. and Tauti, M.:—Apparatus for maintaing a series of constant temperatures. (Jour. Imp. Inst. Vol. XX, No. 4, 1925).

TABLE I.

No. of bath.	1	2	3	4	5	6	7	8	9	10	C.
Mean temperature C° ...	16.9	15.4	14.6	13.1	12.0	10.8	9.2	7.9	6.6	3.1	11.3
Mean variation C°	0.2	0.3	0.4	0.4	0.4	0 5	0.5	0.4	0.9	0.4	0.1
Number of eggs used ...	20	20	20	20	20	20	20	20	20	20	1,122
Number of hatched fry...	0	4	0	6	6	14	11	15	19	7	1,100
Ditto, %	0	20	0	30	30	70	55	75	95	35	98
Number of deformities...	—	2	—	1	2	1	1	4	6	2	3
Ditto, % to hatched fry.	—	50	—	17	33	7	9	27	31	29	0.3
Hatching period	—	27–30/IV	—	1–2/V	4–8/V	9–18/V	15–17/V	24/V–9/VI	11/VI–21/VII	3–29/VIII	5–8/V

Remarks: "C" is the control lot supplied with running water.

The following lines, give a rough outline of the course of development.

Bath No. 1. All the eggs were dead, 11 of which were in an abnormal development, and in the 2 of them embryo was discernible.

Bath No. 2. 4 fries hatched out; but half of them were abnormal.

Bath No. 3. All eggs were dead; only one of them developted in so-colled "eyed-egg" stage.

Bath No. 4 and 5. 30% of the eggs hatched out, but 17～33% of the hatched fries were abnormal.

Bath No. 6—9. More than 27% of the hatched fries were abnormal.

Bath No. 10. 35% of the eggs hatched out and 29% of hatched fries were abnormal.

The following table shows the details of embryos and fries.

TABLE III.

No. of bath.				1	2	3	4	5	6	7	8	9	10	C.
Dead egg.	Blasto-disc obscure			0	0	0	0	0	0	0	0	0	0	16
	Blasto-disc evident			2	0	0	0	0	0	0	0	0	9	1
	Embryo clearness	Undeveloped the eye.	Abnormal or deformed	6	6	15	5	6	0	1	1	1	1	0
			Normal	0	0	5	4	1	0	0	0	0	1	0
		"Eyed-egg."	Abnormal or deformed	5	5	0	1	4	3	4	1	0	1	4
			Normal	7	5	1	4	3	3	4	3	0	1	1
	Total			20	16	20	14	14	6	9	5	1	13	22

	No. of bath.	1	2	3	4	5	6	7	8	9	10	C.
Hatched fry.	Abnormal	—	1	—	0	0	0	0	0	0	0	0
	Deformed	—	1	—	1	2	1	1	4	6	2	3
	Normal	—	2	—	5	4	13	10	11	13	5	1,097
	Total	0	4	0	6	6	14	11	15	19	7	1,100

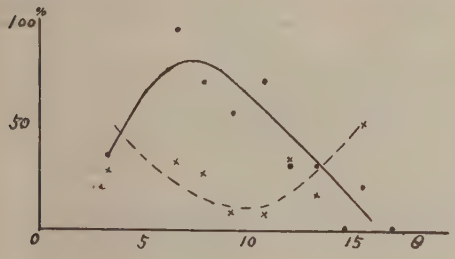

Fig. 1.

•.....Percentage of hatched fries.
×.....Percentage of deformed fries.
θ.....Water temperature.

In Fig. 1 we see that the percentage of the hatched fries is high within 6°~9°C, and the percentage of the abnormal and deformed fries is low within 9°~11°C. Therefore we may say that the optimum temperature lies in about 9°C.

The formula[1] representing the relation between the temperature and the rate of development of fish-eggs, $Te^{a\theta}=C.$, can also be applied in this case as shown in Figs. 2–3 drawn from the Table IV. And we have the following values, $a \log e=0.068$, $C=2.27$, $a=0.16$, $Q_{10}=4.8$.

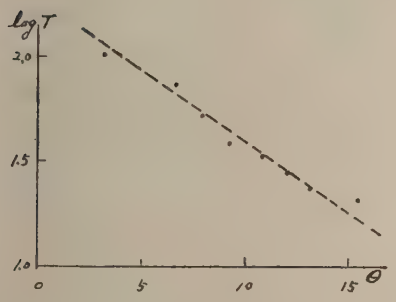

Fig. 2.

log T.....Logarithums of hatching-days.
θ.....Water temperature.

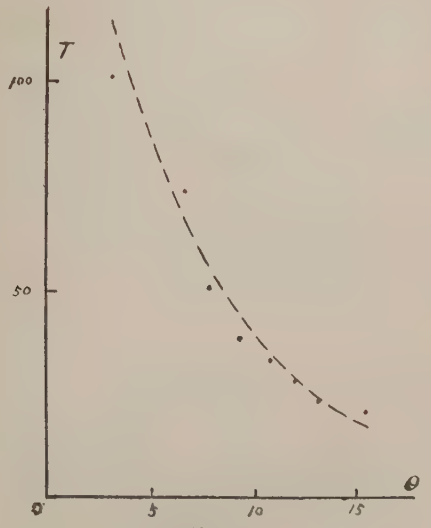

Fig. 3.

T.....Hatching-day.
θ.....Water temperature.
•.....Experimental hatching day.

1) Higurasi, T. and Tauti, M.:—On the relation between temperature and the rate of development of fish-eggs. (Jour. Imp. Fish. Inst. Vol. XXI, No. 1, 1925).

TABLE IV.

No. of bath.	1	2	3	4	5	6	7	8	9	10
Mean temperature C°	16.9	15.4	14.6	13.1	12.0	10.8	9.2	7.9	6.6	3.1
Mean hatching day (T).....	—	20.7	—	23.6	28.2	33.3	38.3	50.6	74.1	102.0
Log. T.	—	1.31	—	1.37	1.45	1.52	1.58	1.70	1.87	2.00
Calculated hatching day	—	16.8	—	24.1	28.5	34.5	42.2	54.2	66.3	114.8

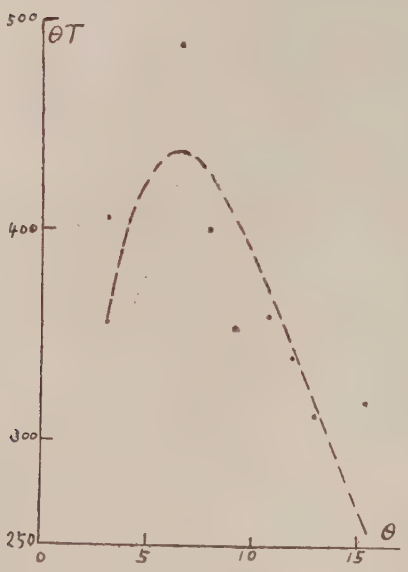

Fig. 4.

θT.....Product of temp. and hatch-days.
θ .....Water temp.
• .....Experimental value.

Between 7° and 11°C, the product of temperature and hatching-days does not varry with the temperature approximatly, and it's value is about 370°~430°C.

The difference of the influence of temperature on hatching between the trout in question (*Salmo irideus* Gibbons) and *Oncorhynchus masou* Brevoort is shown in Table VI, and Figs. 5—6 drawn from Table VI.

From Fig. 5 we learn that, the temperature at which the maximum percentage for hatching of *Salmo irideus* Gibbons is obtained is lower than that of *Oncorhynchus masou* Brevoort, and that the relation between the percentage of abnormal fries and the temperature is the same for both trouts. Then we may say that the optimum temperatures for hatching eggs of *Oncorhynchus masou* Brevoort and *Salmo irideus* Gibbons are nearly same, i.e. about 9°C.

TABLE V.

No. of bath.	1	2	3	4	5	6	7	8	9	10
Mean temperature. C°	16.9	15.4	14.6	13.1	12.0	10.8	9.2	7.9	6.6	3.1
Product of temp. and experimental hatch. day	—	319	—	312	339	359	353	400	489	313
Product of temp. and calculat. hatch. day	—	259	—	316	342	372	388	428	437	356

In Figs. 6 and 7 we know that the hatching-days of the eggs of *Salmo irideus* Gibbons are fewer than those of *Oncorhynchus masou* Brevoort at the same temperature,

第二表　　Table II

D	N.d.	1	2	3	4	5	6	7	8	9	10	C
17/IV	9											2
18	10											1
20	12			1								
22	14	1										
23	15	2		1								1
24	16	1		2								
25	17	1		4								
26	18	7	1	1								1
27	19	3	(2)	5								
28	20	2		4								
29	21	3	1	2								
30	22		5 (1)									1
1/V	23		7 (1)		(2)							
2	24		2		1 (4)	1						1
3	25				1	1					1	2
4	26				4							2
5	27				5	(2)						(61)
6	28					2 (1)						(569)
7	29					(1)						(424)
8	30				3	2 (2)						11 (43)
9	31					3	(7)				2	
10	32					2	(2)				1	
11	33					2	(1)					
13	35					1	1				2	
15	37						2 (2)	(1)				
16	38						(1)	(6)			2	
17	39							(4)				
18	40						(1)			1		
19	41						1	2				
20	42										1	
21	43						1	2			1	
22	44						1	1				
24	46							4	(5)			
28	50								(6)			
30	52								(1)			
1/VI	54								3 (1)			
4	57								1			
9	62								1 (2)			
11	64									(1)		
14	67									(1)		
15	68									(4)		
17	70									(3)		
18	71									(2)		
19	72									(3)		
27	80									(1)		
30	83									(2)		
3/VII	86										(1)	
4	87									(1)		
16	99										(1)	
17	100										1	
20	102										(1)	
21	104									(1)		
22	105										(3)	
24	107										2	
29	112										(1)	
Total		20 (0)	16 (4)	20 (0)	14 (6)	14 (6)	6(14)	9(11)	5(15)	1(19)	13 (7)	22 (1,097)

Explanation of the Table II.

D……date; N. d……Number of days; C……Control lot applied with running water.

Uumerals …… Number of dead eggs; Numerals in brackets …… Number of hatched fries.

Table VI.

Species.	*Salmo irideus* Gibbons.									
No. of bath.	1	2	3	4	5	6	7	8	9	10
Mean temperature. C°.	16.9	15.4	14.6	13.1	12.0	10.8	9.2	7.9	6.6	3.1
Mean variation. C°.	0.2	0.3	0.4	0.4	0.4	0.5	0.5	0.4	0.9	0.4
Percentage of hatched fries	0	20	0	30	30	70	55	75	95	35
Percentage of deformities to hatched fry	—	50	—	17	33	7	9	27	31	29
Calculated hatching days	—	16.8	—	24.1	28.5	34.5	42.2	54.2	66.3	114.8
Product of temp. and calculat. hatch. day	—	259	—	316	342	372	388	428	437	356
$a \log e$	0.068									
Constant	2.27									
a	0.16									
Q_{10}	4.8									

Species.	*Oncorhynchus masou* Brevoort									
No. of bath.	1	2	3	4	5	6	7	8	9	10
Mean temparature. C°.	16.1	14.3	13.0	11.8	10.4	8.8	7.6	6.1	2.9	1.2
Mean variation. C°.	0.4	0.6	0.5	0.5	0.5	0.5	0.5	0.7	0.4	0.3
Percentage of hatched fries	18	28	43	75	70	63	87	80	0	0
Percentage of deformities to hatched fry	28	45	47	26	7	8	9	31	—	—
Calculated hatching days	28.2	34.1	38.9	43.9	51.5	60.9	69.2	80.1	—	—
Product of temp. and calculat. hatch. day	454	487	506	517	536	535	526	489	—	—
$a \log e$	0.046									
Constant	2.19									
a	0.105									
Q_{10}	2.89									

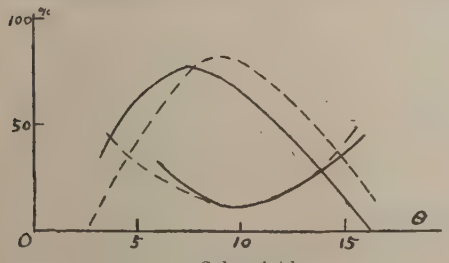

Fig. 5. ——... *Salmo irideus.*
..... *Oncorhynchus masou.*

and that $Q_{10}=4.8$ in the former case, and $Q_{10}=2.89$ in the latter.

And the maximum value of products of temperature and hatching-days of *Salmo irideus* Gibbons is 437°C., but that of *Oncorhynchus masou* Brevoort is 536°C. as shown in Fig. 8.

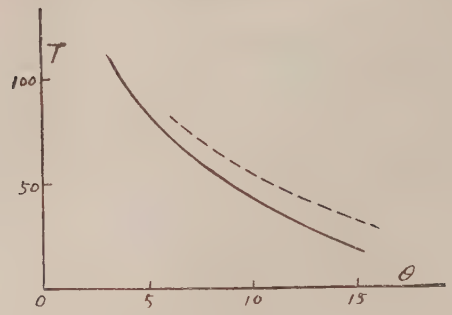

Fig. 6.

——...*Salmo irideus.*
------...*Oncorhynchus masou.*
T.....Hatching day.
θ.....Water temperature.

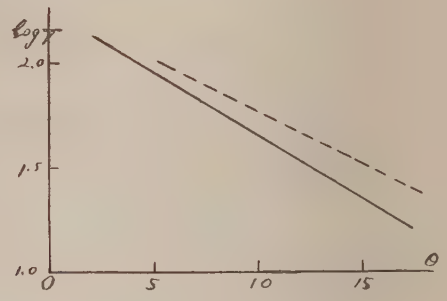

Fig. 7.

——...*Salmo irideus.*
------...*Oncorhynchus masou.*
log T...Logarithums of hatching days.
θ.....Water temperarure.

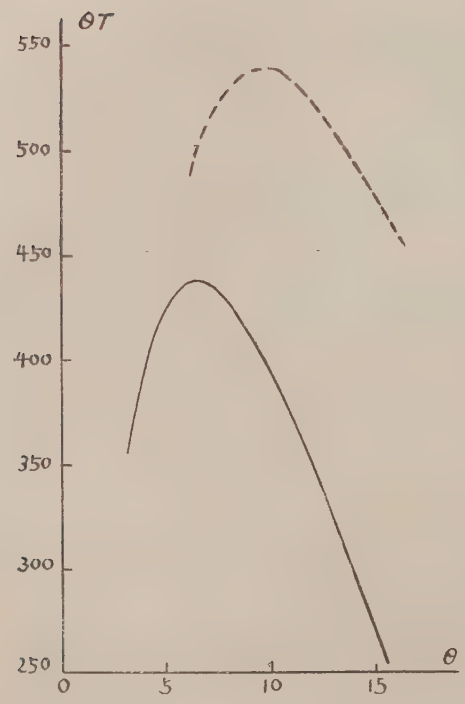

Fig. 8

——...*Salmo irideus.*
------...*Oncorhynchus masou.*
θT.....Product of temp. and hatching-day.
θ .....Water temperature.

Summary.

1. The optimum temperature of hatching eggs of *Salmo irideus* Gibbons is about 9°C.

2. The hatching-days after fertilization descrease when the temperature rises.

3. The formula representing the relation between temperature and rate of development of fish-eggs, $Te^{a\theta}=C.$, can be applied in this case, and the following values are obtained : $a \log e=0.068$, $C=2.27$, $a=0.16$, $Q_{10}=4.8$.

4. In the optimum range of the temperature the product of temperature and hatching-days is about 420°C.

5. The difference of the influence of temperature on hatching between the results of the eggs of *Oncorhynchus masou* Brevoort and those of *Salmo irideus* Gibbons as follows.

a) The temperature, at which the maximum percentage of hatched fries

of *Oncorhynchus masou* Brevoort is obtained, is a little higher than that of *Salmo irideus* Gibbons, but the optimum temperatures of both trouts are almost same and about 9°C.

b) The values of the constant in the formula representing the relation between the temperature and the rate of development are shown in the following table.

TABLE VII.

Species	*Salmo irideus*	*Oncorhynchus masou*
$a \log e$	0.068	0.046
Constant	2.27	2.19
a	0.16	0.105
Q_{10}	4.8	2.89

c) The hatching-days of the eggs of *Salmo irideus* Gibbons are fewer than those of *Oncorhynchus masou* Brevoort at the same temperature.

d) The product of the hatching-days and the temperature of *Salmo irideus* Gibbons is 420°C, in the vicinity of the optimum temperature for hatching, but that of *Oncorhynchus masou* Brevoort is 536°C.

August, 1927. Kizaki Fish-cultural Station, Imp. Fish. Inst.

THE INFLUENCE OF VARIATION OF TEMPERATURE OF WATER ON THE DEVELOPMENT OF FISH-EGGS.

By

Minoru Kawajiri.

This experiment was done to know the influence of the variation of temperature of water on the hatching of the eggs of *Leuciscus hakuensis* Günther and *Carassius auratus* (Linné).

The parent fishes were caught in Lake Kizaki, and the ripened eggs and sperms taken from them were artificially fertilized, and gently spread over a slide glass.

The slide glass was put in a cup containing about 100 c.c. of water, and ten cups were prepared in the same manner. These cups were put in ten chambers of a thermostat,[1] which was regulated to maintain a interrupted series of ten constant temperatures. Twice a day, at 6 o'clock every morning and evening, the cups were interchanged to each other in this way: No. 1 with No. 10 and No. 2 with No. 9 and so on, so as to change the temperature of cups alternately from low to high.

Besides these ten cups I prepared another set of ten cups for control and kept them in the same thermostat without changing their positions during the experiment, so as to give a constant temperature for each of them.

I. The eggs of *Leuciscus hakuensis* Günther were fertilized on 27th May 1927, and put in the thermostat which was regulated to maintain a series of 10 different constant temperatures between 20.3°~6.6°C.

The details of the experiment for the control kept without the variation of temperature are given in Table A and the relation between the temperature and hatched eggs are given in Table I, Figs. 1 and 2 show graphically the relations given in Table I.

TABLE I. Relation between the temperature and hatched eggs calculated from the date mentioned in Table A.

No. of bath.	1	2	3	4	5	6	7	8	9	10
Mean temperature	20.3°C	19.0	18.1	16.9	15.4	14.4	12.7	10.7	9.2	6.6
Mean variation.....	0.6°C	0.7	0.8	0.7	0.8	0.5	0.7	1.0	0.5	0.6
Number of eggs used	85	75	87	106	88	83	93	91	93	111
Number of hatched fries	21	36	50	57	58	74	83	48	47	6
Ditto, %	25%	48	58	54	66	88	89	53	51	5
Number of deformities	7	7	9	14	10	0	0	9	12	6
Ditto, % to hatched fry	33%	19	18	24	17	0	0	19	26	100
Mean hatching days	2.75	3.28	3.86	3.74	4.18	4.75	6.56	7.82	12.61	16.58

The details of the experiment kept under variable temperature are given in Table B and the relation between the temperature and hatched eggs under variable temperature is given in Table II.

From Table II, Figs. 1 and 2 we can calculate the ratio of the percentage of hatched fries under variable temperature to that of those at the same mean temperature

1) Seno, H. and Tauti, M.:—Apparatus for maintaining a series of constant temperatures. (Journ. Imp. Fish. Inst. Vol. XX, No. 4, 1925).

明　細　表

A　Details of the experiment

No.		I			II			III			IV			V			VI			VII			VIII			IX			X		
		tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.
30/V	P.M.	21	14	7																											
31	A.M.				34	28	6	6	6	0	9	7	2																		
	P.M.				2	1	1	27	20	7	40	33	7	6	6	0															
1/VI	A.M.							17	15	2	8	3	5	50	40	10	13	13	0												
	P.M.													1	1	0	26	26	0												
2	A.M.													1	1	0	32	32	0	1	1	0									
	P.M.																—	—	—	5	5	0									
3	A.M.																3	3	0	26	26	0									
	P.M.																			44	44	0	2	2	0						
4	A.M.																			7	7	0	3	3	0						
	P.M.																						32	30	2						
5	A.M.																						10	3	7						
6	P.M.																						1	1	0						
8	A.M.																									8	6	2			
	P.M.																									8	6	2			
9	A.M.																									3	3	0			
	P.M.																									13	10	3			
10	P.M.																									15	10	5			
12	P.M.																												2	0	2
13	A.M.																												2	0	2
14	P.M.																												2	0	2
total		21	14	7	36	29	7	50	41	9	57	43	14	58	48	10	74	74	0	83	83	0	48	39	9	47	35	12	6	0	6

B

No.		I			II			III			IV			V			VI			VII			VIII			IX			X		
		tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.
31/V	A.M.	7	7	0				1	0	1	2	2	0																		
	P.M.	—	—	—				—	—	—	2	2	0																		
1/VI	A.M.	—	—	—	10	10	0	—	—	—	52	38	14	36	34	2	9	9	0	14	14	0	4	4	0				7	3	4
	P.M.	—	—	—				8	7	1	40	33	7	62	59	3	32	32	0	12	10	2	14	14	0	2	2	0			
2	A.M.	1	0	1				—	—	—	5	5	0	—	—	—	7	7	0	10	8	2	56	43	13	50	45	5			
	P.M.							1	0	1	—	—	—	1	1	0							1	1	0	—	—	—			
3	A.M.							—	—	—	—	—	—													—	—	—			
	P.M.							1	1	0	1	1	0													1	1	0			
5	A.M.										1	0	1																		
total		8	7	1	10	10	0	11	8	3	103	81	22	99	94	5	48	48	0	36	32	4	75	62	13	53	48	5	7	3	4

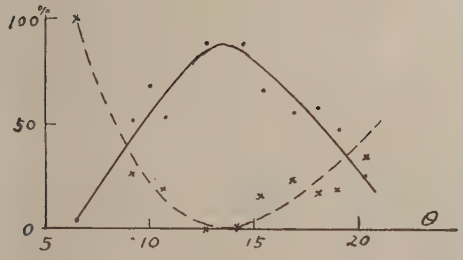

Fig. 1.

Graph showing the relation between the rate of hatched fries, that of deformed fries and the temperature, given in Table 1.

• .....Percentage of hatched fries.
× .....Percentage of deformed fries.
θ .....Water temperature.

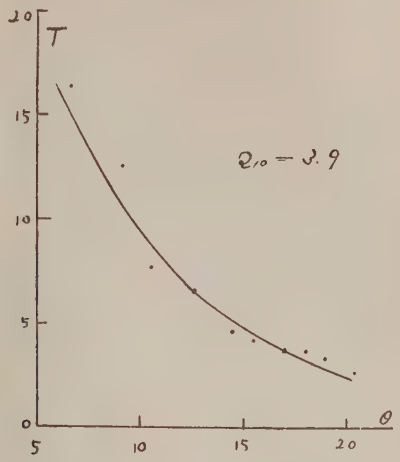

Fig. 2.

Graph showing the number of days used for hatching out and temperature, given in Table 1.

T.....Hatching days.
θ .....Water temperature.

TABLE II.

No. of bath.	1	2	3	4	5
Mean temperature	13.5°C	14.2	14.5	14.8	14.9
Mean variation	6.5°C	4.8	3.5	2.1	0.7
Number of eggs used	186	184	175	215	195
Number of hatched fries.....	15	63	86	139	147
Ditto, %	8%	34	49	64	75
Number of deformities.....	5	5	16	26	5
Ditto, % to hatched fry	33%	8	19	19	3
Mean hatching days	3.8	5.1	5.1	4.6	4.6

with almost no variation. For the ratio of the hatching-days we can calculate in the same way. Table III and Fig. 3 show the relation between the ratio of the percentage of hatched fries and the mean variation of temperature as well as that between the ratio of the hatching-days and the mean variation of temperature.

TABLE III.

No. of bath.	1	2	3	4	5
Mean temperature...	13.5°C	14.2	14.5	14.8	14.9
Mean variation	6.5°C	4.8	3.5	2.1	0.7
Percentage of hatched fries in the case having the variation. (F)	8	34	49	64	75
Calculated percentage of that of control (F').....	89	88	86	83	82
$\frac{F}{F'} \times 100$	9	39	57	77	92
Percentage of hatching days in the case having the variation. (T).....	3.9	5.1	5.1	4.6	4.6
Calculated percentage of that of control. (T')	6.1	5.5	5.3	5.1	5.0
$\frac{T}{T'} \times 100$	62	93	96	90	92

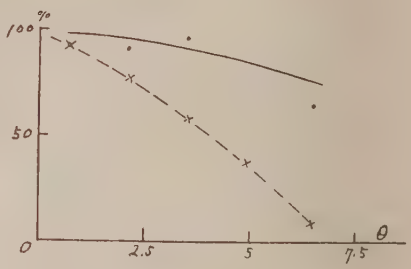

Fig. 3.

•——...$\frac{T}{T'} \times 100$

×-----...$\frac{F}{F'} \times 100$

θ .....Mean variation.

From Fig. 3 we know that the ratio of hatched fries decreases as the mean variation increases and also that the ratio of the hatching-days decreases as the variation increases.

To see the influence of the variation of temperature on the development of embryo, I kept the fertilized eggs at the temperatures, 22.2°C and 10.7°C interchanged alternately at every 6 o'clock as stated before, and get the following results.

1. The rate of development of embryo is little slow at the lower temperature than at the higher.

2. Number of the hatched fries is less at the lower temperature than at the higher as shown in Table IV.

TABLE IV.

	20.2°C		10.7°C	
	Number	Percentage	Number	Percentage
Number of hatched fries in the higher temperature chamber.....	38	97	36	95
Number of hatched fries in the lower temperature chamber.....	1	3	2	5

3. The mean hatching-hours under the variable temperature as stated just above are less than the mean value of the hatching-hours at the temperature, 20.2°C and at 10.7°C of control as shown in Table V.

TABLE V.

	Control		Having the variation of temperature	
Mean temperature	20.2°C	10.7°C	20.2°C at first	10.7°C at first
Hatching-hours.....	83.3	162.2	102.9	109.3
Mean hatching-hours	122.75		106.1	

Again, on the one hand, summing the number of hatched fries (the number mentioned in Tables B and D) in each cup in all cases when that each cup was kept under the high temperature repeatedly, on the other hand, in the same way, summing the number of hatched fries kept under the low temperature also repeatedly, we get the results as shown in Table VI which comfirms the result (2) stated above.

TABLE VI.

	No. of bath.	1	2	3	4	5	6	7	8	9	10	Total	Percentage
Leuciscus hakuensis	Number of hatched fries in the higher chamber.	8	0	11	43	63	16	24	60	51	7	283	63
	Number of hatched fries in the lower chamber.	0	10	0	60	36	32	12	15	2	0	167	37
	Total	8	10	11	103	99	48	36	75	53	7	450	—
Carassius auratus	Number of hatched fries in the higher chamber.	100	83	65	92	53	91	92	68	—	—	644	64
	Number of hatched fries in the lower chamber.	58	51	15	57	45	45	56	39	—	—	366	36
	Total	158	134	80	149	98	136	148	107	—	—	1,010	—

Separately calculating the hatching-days of eggs (the number of the days mentioned in Tables B and D) which were kept under one definite temperature as control, and the other, as well as those of eggs kept under the two definite temperatures just shown interchanged alternately every 6 o'clock, we get the result as shown in Table VII which comfirms the results (3) stated above.

TABLE VII.

	No. of bath.	1	10	2	9	3	8	4	7	5	6
Leuciscus hakuensis Control	Mean hatching days of each chamber	2.75	16.58	3.28	12.61	3.86	7.82	3.74	6.56	4.18	4.75
	Mean hatching days of above two chamber	9.66		7.94		5.84		5.15		4.46	
	Mean hatching days of having the variation of temp.	3.84		5.10		5.10		4.57		4.62	
	No. of bath.	1	8	2	7	3	6	4	5	—	—
Carassius auratus Control	Mean hatching days of each chamber	6.99	23.77	7.74	18.06	8.97	14.84	12.41	12.71	—	—
	Mean hatching days of above two chamber	15.38		12.9		11.90		12.62		—	
	Mean hatching days of having the variation of temp.	11.02		10.99		11.35		10.82		—	

II. The eggs of *Carassius auratus* (Linné) were fertilized at 11th June 1927, and transferred in the thermostat which was regulated to maintain a definite interrupted series of eight different constant temperatures between 17.4°~9.4°C.

The details of the experiment for the control kept without the variation of temperature are given in Table C and the relation between the temperature and hatching eggs is given in Table VIII; Figs. 4 and 5 show graphically the relation given in Table VIII.

TABLE VIII.

No. of bath.	1	2	3	4	5	6	7	8
Mean temperature	17.4°C	16.2	15.8	14.3	13.3	12.0	11.0	9.4
Mean variation	0.6°C	0.5	0.5	0.3	0.3	0.2	0.3	0.4
Number of eggs used	154	115	92	84	156	183	167	119
Number of hatched fry	87	79	58	41	130	132	127	75
Ditto, %	56.5	68.7	63.0	48.8	83.3	72.0	76.0	63.0
Number of deformity	15	11	17	6	16	47	31	43
Ditto, % to hatched fry	17.1	14.0	30.0	14.5	12.3	35.5	24.4	57.3
Mean hatching days	6.99	7.74	8.97	11.41	12.71	14.84	18.06	23.77

The details of the experiment kept under the variable temperature are given in Table D, and the relation between the temperature and the hatching eggs under the variable temperature is given in Table IX.

From Table VIII, Figs. 4 and 5 we can calculate the ratio of the percentage of

No.		I			II			III			IV			V			VI			VII			VIII		
		tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.
16/VI	P.M.	3	3	0																					
17	A.M.	17	17	0	2	2	0																		
	P.M.	15	15	0	9	9	0																		
18	A.M.	13	11	2	9	9	0																		
	P.M.	13	11	2	16	16	0	6	5	1															
19	A.M.	12	11	1	37	28	9	10	8	2															
	P.M.	1	1	0	—	—	—	8	8	0															
20	A.M.	3	1	2	1	1	0	10	6	4	1	1	0	1	1	0									
	P.M.	—	—	—	3	3	0	4	3	1	3	3	0	—	—	—									
21	A.M.	8	1	7	—	—	—	11	8	3	3	2	1	—	—	—									
	P.M.	—	—	—	—	—	—	—	—	—	5	4	1	2	2	0									
22	A.M.	1	0	1	—	—	—	2	1	1	2	2	0	8	8	0									
	P.M.	—	—	—	—	—	—	1	1	0	15	15	0	—	—	—									
23	A.M.	—	—	—	2	0	2	3	0	3	1	1	0	11	10	1	4	2	2						
	P.M.	—	—	—				—	—	—	4	4	0	29	29	0	5	5	0						
24	A.M.	—	—	—				—	—	—	—	—	—	41	36	5	16	16	0						
	P.M.	—	—	—				—	—	—	1	0	1	2	2	0	5	5	0						
25	A.M.	—	—	—				1	0	1	2	2	0	17	12	5	16	11	5						
	P.M.	—	—	—				—	—	—	—	—	—	1	1	0	3	2	1						
26	A.M.	—	—	—				2	1	1	1	1	0	9	9	0	28	18	10	3	2	1			
	P.M.	—	—	—							—	—	—	2	1	1	3	2	1	—	—	—			
27	A.M.	—	—	—							—	—	—	4	1	3	22	9	13	21	17	4			
	P.M.	—	—	—							—	—	—	—	—	—	1	1	0	3	3	0			
28	A.M.	—	—	—							1	0	1	1	0	1	15	6	9	13	13	0			
	P.M.	—	—	—							2	0	2	1	1	0	—	—	—	4	3	1			
29	A.M.	—	—	—										1	1	0	3	2	1	18	16	2			
	P.M.	—	—	—													1	1	0	5	5	0	2	2	0
30	A.M.	1	1	0													3	3	0	31	15	16	7	1	6
	P.M.																3	0	3	7	6	1	3	2	1
1/VII	A.M.																1	0	1	1	1	0	—	—	—
	P.M.																—	—	—	—	—	—	—	—	—
2	A.M.																3	2	1	7	3	4	1	0	1
	P.M.																			1	1	0	—	—	—
3	A.M.																			4	4	0	4	4	0
	P.M.																			1	1	0	1	1	0
4	A.M.																			7	6	1	11	5	6
	P.M.																			—	—	—	1	1	0
5	A.M.																			—	—	—	—	—	—
	P.M.																			1	0	1	1	0	1
6	A.M.																						25	6	19
	P.M.																						1	1	0
7	A.M.																						2	1	1
	P.M.																						—	—	—
8	A.M.																						8	4	4
	P.M.																						—	—	—
9	A.M.																						4	3	1
	P.M.																						—	—	—
10	A.M.																						1	1	0
	P.M.																						4	0	4
total		87	72	15	79	68	11	58	41	17	41	35	6	130	114	16	132	85	47	127	96	31	76	32	44

No.		I			II			III			IV			V			VI			VII			VIII		
		tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.	tot.	nor.	abn.
19/VI	P.M.																3	3	0	1	1	0	4	4	0
20	A.M.	5	5	0	16	16	0	3	3	0	1	1	0				3	3	0	2	2	0	1	1	0
	P.M.	—	—	—	9	8	1	—	—	—	6	5	1	11	10	1	26	25	1	25	25	0	14	12	2
21	A.M.	33	32	1	29	28	1	13	12	1	23	23	0	14	13	1	16	15	1	12	10	2	10	3	7
	P.M.	15	14	1	4	4	0	—	—	—	33	28	5	32	26	6	42	40	2	24	23	1	25	25	0
22	A.M.	1	1	0	8	8	0	9	3	6	37	27	10	16	10	6	20	18	2	27	25	2	24	9	15
	P.M.	36	35	1	6	6	0	10	9	1	13	11	2	6	4	2	2	2	0	—	—	—	—	—	—
23	A.M.	4	4	0	6	6	0	—	—	—	1	1	0	3	3	0	—	—	—	6	6	0	7	6	1
	P.M.	19	18	1	18	17	1	25	10	15	16	16	0	7	4	3	4	3	1	15	12	3	4	4	0
24	A.M.	21	13	8	15	11	4	1	1	0	6	5	1	5	3	2	13	13	0	22	14	8	8	2	6
	P.M.	2	2	0	8	8	0	1	0	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	A.M.	8	6	2	4	4	0	1	1	0	5	4	1	—	—	—	5	4	1	—	—	—	3	3	0
	P.M.	2	2	0	3	3	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26	A.M.	6	4	2	5	2	3	1	0	1	2	0	2	—	—	—	1	1	0	13	5	8	2	2	0
	P.M.	1	1	0	1	1	0	—	—	—	—	—	—	1	1	0	—	—	—	—	—	—	—	—	—
27	A.M.	—	—	—	—	—	—	8	3	5	—	—	—	1	1	0	—	—	—	1	1	0	4	0	4
	P.M.	—	—	—	1	1	0	—	—	—	—	—	—	—	—	—	—	—	—				—	—	—
28	A.M.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	0				—	—	—
	P.M.	1	1	0	1	0	1	2	1	1	2	1	1	—	—	—							—	—	—
29	A.M.							—	—	—	—	—	—	—	—	—							—	—	—
	P.M.							—	—	—	—	—	—	1	0	1							—	—	—
30	A.M.							—	—	—	—	—	—	—	—	—							—	—	—
	P.M.							3	2	1	1	0	1	—	—	—							—	—	—
3/VII	A.M.							—	—	—	1	1	0	1	1	0							1	0	1
4	A.M.							1	0	1	—	—	—												
8	A.M.							2	2	0	2	1	1												
total		154	138	16	134	123	11	80	47	33	149	124	25	98	76	22	136	128	8	148	124	24	107	71	36

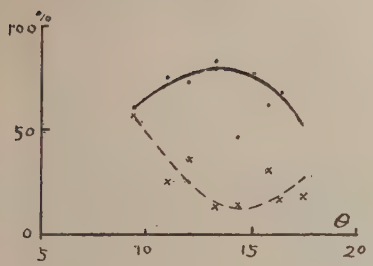

Fig. 4.

•.....Percentage of hatched fries.
×.....Percentage of deformed fries.
θ.....Water temperature.

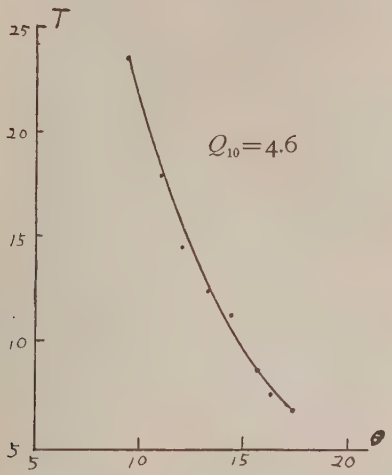

Fig. 5.

T.....Mean hatching-days.
θ.....Water temperature.

TABLE IX.

No. of bath.	1	2	3	4
Mean temperature	13.3°C	13.6	13.9	13.8
Mean variation	3.8°C	2.5	1.9	0.5
Number of eggs used	377	396	310	344
Number of hatched fry	261	282	216	247
Ditto, %.....	69.2	71.2	69.7	71.8
Number of deformity	52	35	41	47
Ditto, % to hatched fry.....	19.9	12.4	18.9	19.0
Mean hatching days.....	11.02	10.99	11.35	10.82

hatched fries in the variable temperature with that of those in the same mean temperature having almost no variation. For the ratio of the hatching-days we can calculate in the same way. Table X and Fig. 6 show the relation between the mean variation of temperature and the ratios of the percentage of hatched fries and of the hatching-days.

In Fig. 6 we see that the ratio of hatched fries decreases as the mean variation of temperature increases and also that the ratio of the hatching-days decreases as the variation increases.

TABLE X.

No. of bath.	1	2	3	4
Mean temperature	13.3°C	13.6	13.9	13.8
Mean variation.....	3.8°C	2.5	1.9	0.5
Percentage of hatched fries in the case having the variation. ($F.$)...	69.2	71.2	69.7	71.8
Calculated percentage of that of control. ($F.'$).....	77	77	77	77
$\frac{F}{F'} \times 100$	90	92	91	93
Percentage of hatching days in the case having the variation. ($T.$)...	11.02	10.99	11.35	10.82
Calculated percentage of that of control. ($T'.$).....	12.7	12.0	11.5	11.5
$\frac{T}{T'} \times 100$	87	92	99	94

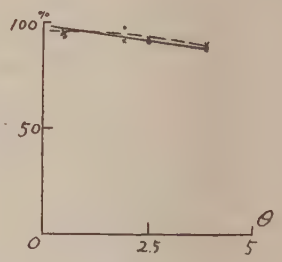

Fig. 6.

•——...$\frac{T}{T'} \times 100$

×- - - - -...$\frac{F}{F'} \times 100$

θ .....Mean variation.

To compare the influence of the mean variation of temperature upon the hatching of eggs of *Leuciscus hakuensis* and of *Carassius auratus*, I summarize the relations between the mean variation of temperature and the ratio of hatched fries of the both eggs and also the relation between the mean variation and the ratio of hatching-hours in Table XI and Figs. 7 and 8.

TABLE XI.

Kind of egg.	*Leuciscus hakuensis.*					*Carassius auratus.*			
No. of bath.	1	2	3	4	5	1	2	3	4
Mean temperature	13.5°C	14.2	14.5	14.8	14.9	13.3	13.6	13.9	13.8
Mean variation	6.5°C	4.8	3.5	2.1	0.7	3.8	2.5	1.9	0.5
$\frac{F}{F'} \times 100$	9	39	57	77	92	90	92	91	93
$\frac{T}{T'} \times 100$	62	93	96	96	92	87	92	99	94

Fig. 7 shows that the hatching-hours of the eggs of *Leuciscus hakuensis* and *Carassius auratus* are equally influenced by the variation of the temperature. But Fig. 8 shows that with respect to the percentage of hatched fries, the eggs of *Leuciscus hakuensis* are more seriously affected by the variation of the temperature than the eggs of *Carassius auratus*.

Looking at Figs. 8 and 9 we may infer that the influence of the variation of temperature upon the percentage of hatched fries strengthens as the sharpness of the

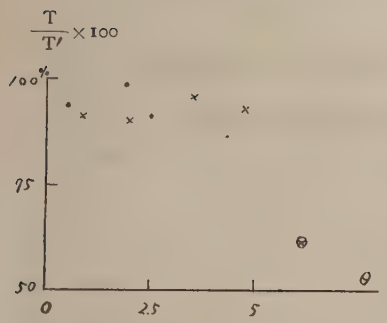

Fig. 7.

• .....*Leuciscus hakuensis.*
×.....*Carassius auratus.*
⊗.....Except of *C.a.*
θ .....Mean variation.

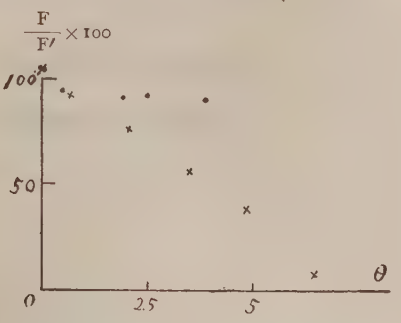

Fig. 8.

• .....*Leuciscus hakuensis.*
×.....*Carassius auratus.*
θ .....Mean variation.

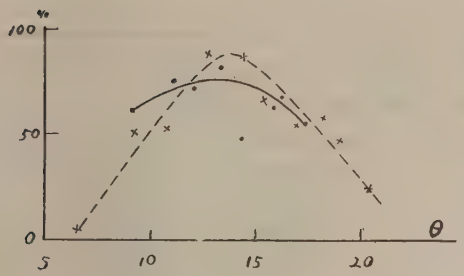

Fig. 9.

• ——...*Leuciscus hakuensis.*
×-----...*Carassius auratus.*
θ .....Water temperature.

curve representing the relation between the temperature and the percentage of hatched fries increases.

Before closing the paper, I wish to express my sincere thanks to Dr. M. Tauti for his helpful advice.

Summary.

1. When the mean temperature remains the same, the percentage of hatched fries and the hatching-days of eggs of *Luciscus hakuensis* Günther decrease as the mean variation of temperature increases.

2. The eggs of *Carassius auratus* (Linné) are affected in the same manner by the variation.

3. The decrease of the percentage of hatched fries of *Leuciscus hakuensis* Günther under the influence of the variation of temperature is larger than that of *Carassius auratus* (Linné), and this difference is inferred by that the curve representing the relation between the temperature and the percentage of hatched fries of the eggs of the former fish is more sharp than that of those of the latter fish.

August, 1927. Kizaki Fish-cultural Station, Imp. Fish. Inst.

On the influence of four kinds of vibration upon the eggs of *Oncorhynchus masou* Brevoort.

By

Kyuzo Hata.

The purpose of the present experiment is to know that what various vibrations how influence upon the eggs during their development.

The experiment was done thrice during the period form November 14, 1926 to January 11, 1927, giving four kinds of vibrations to the eggs in the following 11 stages of development :—

(I)	Soon after fertilization	——	The protoplasmic blasto-disc protrudes.
(II)	1st after	,, ——	The blasto-disc develops into the 16 cell stage.
(III)	5th after	,, ——	The blasto-disc develops into the later cleavege stage.
(IV)	10th after	,, ——	The outline of the fish body appears distinctly.
(V)	15th after	,, ——	The "anlage" of optic vesicle become a little visible.
(VI)	20th after	,, ——	The somites of the fish body become clearly visible.
(VII)	25th after	,, ——	The lens vesicle and pectoral fin become clearly visible.
(VIII)	30th after	,, ——	The heart and blood vessel become clearly visible.
(IX)	35th after	,, ——	All part of the fish body become clearly visible.
(X)	40th after	,, ——	The pigment develops and the embryo moves frequently.
(XI)	45th after	,, ——	The embryo develops more than X.

The arrangement of vibration-apparatus (as shown in Fig. 1) is provided with 4 rectangular boxes (Fig. I, 1) each of which having four compartments (I, II, III, and IV) on a desk (Fig. I, 2). The one end (Fig. I, 3) of every box is hinged and the opposite free end (Fig. I, 4) rests on either one of cog-wheels (Fig. I, 5) of four types, through which a shaft (Fig. I, 6) is fixed as shown in Fig. II. The terminal end of the shaft is fixed with metal (Fig. I, 7) and the fly-wheel (Fig. I, 8) on the other end is revolved by an electric motor. By this arrangement one may easily understand that when the fly-wheel rotates the eggs in the box resting on either one of 4 types of cog-wheels are afflicted with sudden vibrations by the cog-wheels *A*—*C* and gentle vibration by *D*. The fly-wheel rotates 53–56 times a minute.

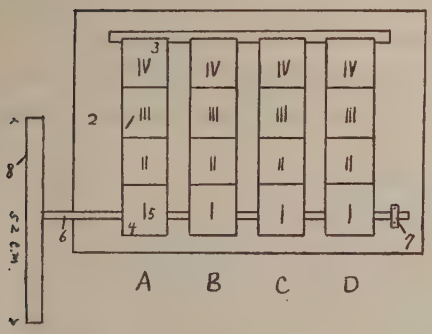

Fig. I.

The plan of the instrument

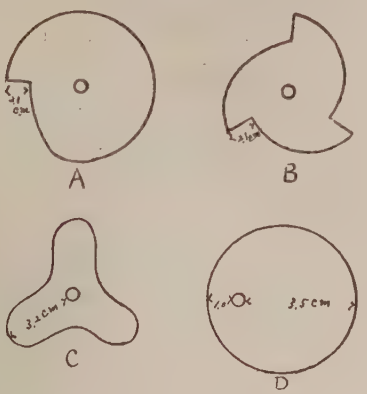

Fig. II. Cog-wheels.

The compartments I and IV of the boxes resting on either one of the cog-wheels A and D were submitted to the experiment. About 50 eggs in the stage of development above specified, were carefully scattered evenly over wet moss in a cup fixed in each of the four compartments—A_I, A_{IV}, D_I, D_{IV}—and the fly-wheel was rotated for 5 minutes at each experiment. Then the eggs were transferred into the hatching apparatus which was supplied with running water of 10.°7～11.°5C.

As control, non vibrated eggs were kept in the same apparatus.

The developmental stages of these eggs were observed day by day.

The result of the experiment is shown in Table I.

If N fries are obtained among N_o eggs which have been acted upon by the vibration A_I, at t days after the fertilization, $\frac{N_o-N}{N_o}\times 100$ is the percentage of the eggs died under the action of the vibration A_I. Again if N' fries are obtained among N_o' eggs at t days after the fertilization, $\frac{N_o'-N'}{N_o'}\times 100$ is the percentage of the eggs died under natural conditions. Then $\left(\frac{N_o-N}{N_o}-\frac{N_o'-N'}{N_o'}\right)\times 100$ is the percentage of the eggs died due to the vibration A_I at t days after the fertilization.

Fig. III shows the relation between the percentage of dead eggs $\left(\frac{N_o-N}{N_o}-\frac{N_o'-N'}{N_o'}\right)\times 100$ and the time t at which the vibration is acted upon the eggs. From Fig. III we know that the influence of the action of the vibration is most powerful

when it is acted upon soon after the fertilization and equally powerful from 10 to 15 days after the fertilization and that the influence is neglisible afterwards from 25 days after the fertilization. With respect to the kind of vibrations, as shown in Fig. III, the influence of the blow type of vibration (A_I, A_{IV}) is more injurious than that of the oscillation type of vibration (D_I, D_{IV}).

Fig. III. Graph showing the relation between the percentage of dead eggs and the time at which the vibration is acted upon the eggs.

TABLE I.

Days after the fertilization.		Soon after	1	5	10	15	20	25	30	35	40	45
Contrast	Number of eggs received. N_o'	140	140	140	137	125	104	91	80	64	59	59
	Number of dead eggs. $N_o'-N'$	81	81	81	78	66	45	32	21	5	0	0
	$\frac{N_o'-N_o'}{N_o'} \times 100$	57.8	57.8	57.8	56.9	52.8	43.2	35.1	26.2	7.8	0	0
Number of rotation per minute.		54.6	54.6	54.3	54.6	50.0	53.6	54.6	53.6	54.3	53.0	54.0
Vibration A_I	Number of eggs received. N_o	148	145	142	148	147	145	119	117	106	70	50
	Number of dead eggs. N_o-N	142	109	88	132	131	67	49	35	9	1	0
	$\frac{N_o-N}{N_o} \times 100$	95.9	75.1	61.9	89.1	89.1	46.2	41.1	29.9	8.5	1.4	0
	$\left(\frac{N_o-N}{N_o}-\frac{N_o'-N'}{N_o'}\right) \times 100$...	38.1	17.3	4.1	32.2	36.3	3.0	6.0	3.7	0.7	1.4	0
	Number of deformities.	0	0	0	0	0	0	2	0	0	4	0
	Number of uncom. hatched.	0	3	2	2	2	4	11	3	9	6	0

	Days after the fertilization.	Soon after	1	5	10	15	20	25	30	35	40	45
Vibration A_{IV}	Number of eggs received. N_o	147	145	149	149	150	143	119	117	113	70	50
	Number of dead eggs. N_o-N	140	109	97	132	124	60	32	11	4	0	0
	$\frac{N_o-N}{N_o}\times 100$	95.2	75.1	65.1	88.5	82.6	41.9	26.8	9.4	3.5	0	0
	$\left(\frac{N_o-N}{N_o}-\frac{N_o'-N'}{N_o'}\right)\times 100$...	37.4	17.3	7.3	31.6	29.8	−1.3	−8.3	−16.8	−4.3	0	0
	Number of deformities.	0	0	0	0	0	0	1	4	2	2	0
	Number of uncom. hatched.....	4	2	12	6	5	6	8	2	4	4	0
Vibration D_I	Number of eggs received. N_o	144	145	142	136	149	147	118	114	114	70	50
	Number of dead eggs. N_o-N	121	86	100	98	123	58	16	47	15	1	0
	$\frac{N_o-N}{N_o}\times 100$	84.0	59.3	70.4	72.0	82.5	39.4	13.5	41.2	13.1	1.4	0
	$\left(\frac{N_o-N}{N_o}-\frac{N_o'-N'}{N_o'}\right)\times 100$...	26.2	1.5	12.6	15.1	29.7	−3.8	−21.6	15.0	5.3	1.4	0
	Number of deformities.	0	0	3	0	1	4	3	0	0	1	0
	Nnmber of uncom. hatched.....	7	3	6	2	2	5	5	3	15	9	0
Vibration D_{IV}	Number of eggs received. N_o	129	142	140	137	144	145	116	122	103	68	50
	Number of dead eggs. N_o-N	110	96	115	98	127	28	27	29	7	1	0
	$\frac{N_o-N}{N_o}\times 100$	85.2	67.6	82.1	71.7	88.1	19.3	23.2	23.7	6.7	1.4	0
	$\left(\frac{N_o-N}{N_o}-\frac{N_o'-N'}{N_o'}\right)\times 100$...	27.4	9.8	24.3	14.8	35.3	−23.9	−11.9	−2.5	−1.1	1.4	0
	Number of deformities.	1	0	0	0	0	1	1	1	0	1	1
	Number of uncom. hatched.....	3	10	3	13	6	5	5	3	7	6	0

Before closing, I wish to express my vest thanks to Dr. M. Tauti and to Mr. M. Kawajiri for their kind advices and helps.

Summary.

1. The influence of vibration upon the eggs of the *Oncorhynchus masou* Brevoort is most powerful soon after the fertilization and equally powerful from 10 to 15 days after the fertilization and the influence is neglisible afterwards from 25 days after the fertilization.

2. The influence of the blow type of vibration is more injurious than that of the oscillation type.

March, 1927. Kizaki Fish-cultural Station, Imp. Fish. Inst.

NEUE GRÜNE ALGE ALS NAHRUNG FÜR DIE SCHALEN-LARVEN DER AUSTER.

Von

S. Ueda.

Eine grüne Alge ist als primäre Nahrung für die jünge larven der Auster im zoologischen Laboratorium an dem kaiserlichen Fischerei-Institute von Herrn J. Hori und anderen kultiviert. Ich wurde von Herrn J. Hori aufgetragen die Art dieser Alge zu bestimmen. Ich habe die Alge als eine neue Art von Gattung *Chlorella* (Beyerinck 1890) bestimmt. Die Diagnose der Art ist folgende.

Chlorella pacifica Ueda sp. nov.

Die Zellen leben einzeln ohne Eigenbewegung und sind kugelig, 2μ–4μ dick, mit einer sehr dünnen Membran und einem wandständigen Chromatophor von der Gestalt einer Kugelsegmentschale oder Glocke. Zellkern 1. Pyrenoid undeutlich. Assimilationsproduct Stärke. Vermehrung geschieht durch sukzessive Zweiteilung und Aplanosporen. Bei der Teilung der Aplanosporen zerfällt der Zellinhalt in 4 Mutterzelle ähnliche Tochterzellen, die sich noch innerhalb der Mutterzellmembran mit neuen Membranen umgeben und schliesslich durch Zerreissen der Mutterzellmembran frei werden. Schwärmsporen und geschlechtliche Fortpflanzung fehlen.

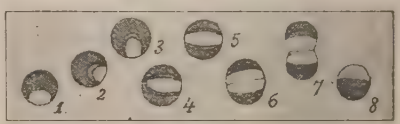

Fig. 1.
Vegetative Zellen von gewöhnlichem Grosse im Tweiteilungsvorgang.

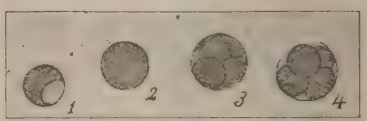

Fig. 2.
Etwas grössere Zellen in der Aplanosporenbildung.

Vorkommen. Im Brack- oder Seewasser entlang der Küsten des Pacifischen Ozeans. Kanazawa, Kanagawa-Ken und Futami, Hyogo-Ken.

ON THE ARTIFICIAL CULTURE OF OYSTER LARVAE. (II)

By

Juzo Hori and Daijiro Kusakabe.

We have already reported[1] on the artificial culture of oyster larvae by supplying a minute species of unicellular green alga as food, namely, *Palmellococcus sp.* This alga has been revised later by Mr. Ueda after his careful identification and is now called *Chlorella pacifica Ueda.*[2]

Last year, we were unable to complete the culture of the larvae to the full grown stage, but this summer we have succeeded in raising them to the stage of their final attachment by an artificial fertilization.

The eggs of the oyster (*Ostrea gigas*) were artificially fertilized on the 6th of July 1927. They developed normally and attained the stage of young shelled-larvae about twenty four hours after the fertilization. From this stage onwards we continued the culture of the larvae in 15 cm. Petri dishes supplying them a minute alga *Chlorella pacifica* as food. The cultural water was renewed daily at first, but afterwards at intervals of three or four days. The larvae fed upon the food and grew rapidly to a healthy condition. In about three weeks they attained about 280μ in length, and some were creeping on the bottom of the dishes by the aid of foot. On the 29th of July (23 days after the fertilization), one of the larvae attached itself to the bottom and after a week we found five spats attached. We continued the culture of the remaining larvae, but they gradually died without attaching by injury of Infusoria.

The specific gravity of the sea water emplyed was about 1.019—1.021 at 15.°C. The temperature in the course of the experiment fluctuated between 23°.0 and 32°.2C; the average at 10 a.m. was 28.°1C.

September, 1927. Kanazawa Oyster Experimental Station, Imp. Fish. Inst.

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1) Hori, J. and Kusakabe, D.—Preliminary experiment on the artificial culture of oyster larvae. (Journ. Imp. Fish. Institute, Vol. XXII, No. 3, 1926).

2) Ueda, S: Neue grüne Alge als Nahrung für die Schalen-larven der Auster onp. of this number.

RELATION BETWEEN THE DAILY CATCH OF FISH AND THE METEOROLOGICAL ELEMENTS.—PART I. STATISTICAL STUDIES IN THE INFLUENCE OF THE MOTION OF CYCLONE UPON THE FISHING.

By

Mititaka Uda.

The materials utilized in the following study have been taken from the daily records of the catch of "*Buri*" (*Scriola quinqucradiata* Temminck and Schlegel) by means of *Ôsikiami* (a kind of pound net), kept during 9 years from 1918 to 1926 at Nisimura Fishing Station in Nagasaki Prefecture. The method of procedure adopted is as follows:

The day on which the centre of any cyclone is located nearest to the station above mentioned is taken as the origin of time i.e. 0 day, which can easily be determined from the weather chart. The day before 0 day is taken as −1 day, the next day as +1 day and so on. In order to see the distribution of the catch during a period of a few days before and after 0 day, the daily catch of fishes is then tabulated as indicated in Table I.

TABLE I 1925 (Taisyô 14 nen.) The catch of "*Buri*" at Nisimura Fishing Station in Nagasaki Prefecture.

The date of 0 day \ day	−4	−3	−2	−1	0	1	2	3	4
II. 6	18	61	26	2	0	0	679	2037	0
	2	0	0	679	2037	0	1615	4845	0
16	4845	0	0	0	0	0	0	0	0
27	0	388	1162	0	0	0	0	0	1979
III. 1	1162	0	0	0	0	0	1979	5935	63
4	0	0	0	1979	5935	63	189	455	1771
9	63	189	455	1771	1223	0	0	403	1209
11	455	1779	1223	0	0	403	1209	455	1937
15	0	403	1209	452	1937	1746	0	0	0
23	0	22	66	609	1825	0	0	0	1081
27	1825	0	0	0	1081	3233	0	1739	5233
30	0	1081	3233	0	1739	5233	42	0	0

The date of o day \ day		−4	−3	−2	−1	0	1	2	3	4
IV.	2	0	1739	5233	42	0	0	0	30	4641
	4	5233	42	0	0	0	30	4641	13703	147
	8	0	30	4641	13703	147	2863	8589	36	107
	12	147	2863	8589	36	107	0	58	174	0
	15	36	107	0	58	174	0	0	0	0
	21	0	0	0	0	0	0	0	2234	6701
	28	2234	6701	0	47	142	2534	7800	602	0
The total sum in each column		16020	15405	25837	19378	16338	16105	26801	32645	28869

In the present investigation the variety in the course and other characteristics of each cyclone are put aside. The discussion on these points involves, indeed, many important problems relating to the effects of the tidal currents, the topographical feature of the bay, etc., which are intended to be discussed in other days.

For the present, however, we will confine our study to the statistical results regardless of the intensities of various cyclones.

It must be remarked here that unfortunately our records are destitute of the separate descriptions of the catch of fish obtained by the morning-net[1] and that by the evening-net[2] respectively, except in those of 1926.

Therefore, the author has tried to take this fact into account by transferring one fourth of the catch into that of the day before. The number of catch given in Table I represents the values thus reduced to the value of the catch at noon of the day considered. In this way, Table I still contains the whole of the catch without any omission.

In Table II is given yearly catch for each of the nine years.

With a view to make the statistical results of Table II more obvious, the total sum of

Table II.

Year \ day	−4	−3	−2	−1	0	1	2	3	4
7	4983	10836	4429	3275	734	2268	8454	6454	4053
8	21871	26256	27221	25152	16972	17995	35893	21731	17299
9	11384	11371	12432	11316	9812	9615	19324	8184	5730
10	3779	2707	9451	11293	5700	3227	3605	5494	8510

1) It means the net which is laid at about 6h P.M. of the preceding day and hoisted at about 6h A.M. on the day.

2) The net laid at about 6h A.M. and hoisted at about 6h. P.M.

Year \ day	−4	−3	−2	−1	0	1	2	3	4
11	2237	3596	4502	3359	3890	3395	5000	4386	3616
12	3995	4457	2054	2232	1382	1670	3770	5265	1026
13	90	560	973	383	243	287	738	248	80
14	16020	15405	25837	19378	16338	16105	26801	32645	28869
15	7792	14196	20688	23844	9021	6532	11274	13610	20044
The total sum in each column	72171	89384	107587	100232	64092	65074	114859	98020	89221

each column is plotted in Fig. I, where N′ denotes the number of the catch and t, the time.

As seen from Table I, the mode of distribution of the catch before and after the day on which the centre of a cyclone is located nearest to our fishing station is rather obscure.

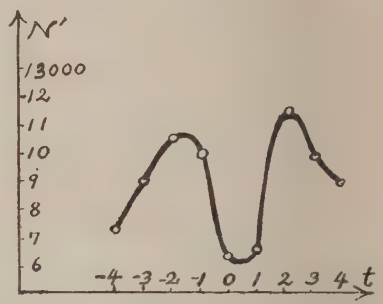


Fig. I.

From Table II, however, we recognize a remarkable feature common to every year for the modes of distribution of the catch. Moreover, we see that the minimum of the catch curve throughout 9 years coincides with the position of the time axis corresponding to +0.5 day (half a day after 0 day). We can also easily notice that the maxima are two in number before and after 0 day, the one lying between −3 day and −1 day and the other, between +2 day and +3 day. The author attributes the cause of the slight discordane of the positions of these maxima in different years to the yearly differences in the intervals between the days of successive approaches of cyclones. On account of the yearly differences in the modes of superposition on the catch-curves of the influences of the consecutive cyclones, the values of catch for ±3 day or ±4 day are more or less different for different every year. Calculating the average time-interval for the successive approaches of the cyclones accompanied by amounts of the catch above 1000 in the fishing-season now in problem and superposing the curve displaced by the time interval thus obtained upon the original catch-curve, he ascertained that the idea above stated is pretty correct. Supposing, however, that by taking the statistical mean for 9 years the accidental discordances of maxima above stated may cancel each other for the most parts (the both ends of the curve in Fig. I are excepted), he considered that the total sum of each column in Table II may represent the general features of the catch-curve. Thus, Fig. I was constructed.

In the author's opinion the positions of the minimum and the maxima represented in this curve may play a role very important for the practice of stationary fishing. The minimum lies at +0.5 day, while the maxima are two in number, of which the one corresponds to −1.5 day and the other to +2.5 day. By these results the empirical facts known to the fishermen as "*Maeryô*" (Prefishing[1]) and "*Atoryô*" (Postfishing[1]) are proved statistically. There is a general belief among the fishermen at Nisimura Fishing Station that NNE wind in this season brings a hopeful catch. This can be easily explained, since the wind blowing counter-clockwise about the centre of a cyclone appears as NNE wind as the cyclone approaches to the fishing station from SWW to NEE on the south side. And, moreover, remembering that the mouth of the bay faces toward the north, it is probable that this wind is most effective in stirring the water of bay and thus serving to induce the fish towards the fishing station. Therefore, a sudden change of wind from the normal direction (NW∼W) to NNE may be considered as a prediction of the approach of the centre of a cyclone or indirectly of an abundant catch.[2]

Again, to analyse the character of the curve above obtained a little further, let us evaluate the ratio, $\frac{\text{maximum value}-\text{minimum value}}{\text{average value}}=\frac{\text{amplitude}}{\text{average value}}$, We obtain a value $\frac{58000}{89000}=0.65$.

Now calculating the frequency of the catch above 1000 (n) for the days before and after 0 day respectively, we have the results as shown in Table III. Fig. II. shows the results diagrammatically.

Tabee III.

Year \ day	−4	−3	−2	−1	0	1	2	3	4
7	3	2	2	2	0	1	4	1	2
8	7	6	9	7	4	5	10	7	4
9	3	3	3	3	2	3	3	2	2
10	2	0	4	4	3	1	1	3	2
11	2	1	2	2	2	1	3	0	4
12	1	2	0	1	0	0	1	2	0
13	0	0	0	0	0	0	0	0	0
14	5	5	7	3	7	5	6	6	8
15	2	5	7	4	3	2	3	4	4
Total sum in each column	25	24	34	26	11	18	31	25	26

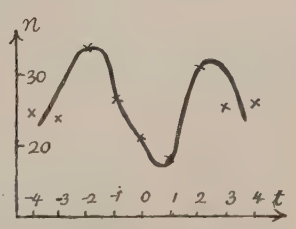


Fig. II.

1) By Pre-and Post-fishing the author means the catch before and after the approach of a cyclone.

2) The author may add in passing that the cyclones which has brought the catch of "*Buri*" in the fishing season are mostly those of Tairiku Senpû (cyclones which are originated from the interiors of Asia Continent and attack Japan Island, generally in winter), especially those of which run from SWW to NEE on the south side of this fishing station.

Glancing at Fig. II, we notice a remarkable resemblance between Fig. II and Fig. I. Further, calculating the ratio $\frac{\text{amplitude}}{\text{average value}}$ from Fig. II we have 0.66. By the way, we have $\frac{\text{amplitude}}{\text{average value}} = 0.4$ from the frequency-curve of the catch above 1, and 0.57, from that above 700.

Therefore, the unit of shoals of "*Buri*" may be supposed to be that of the order of 1000. Referring again to Fig. I, we may explain the meaning of that figure as follows. The shoal of "*Buri*," with the number of fish (N) enters into the bay most abundantly when the sea is raging most violently, as is believed generally.

Since the rate of net-reeling (K) becomes worse as the violence of the sea increases, the so called number of the catch N′ is KN ; therefore, we have the form of the curve as Fig. I.

To test this idea, the author has tried the following check. Namely, using the material in 1926 with the records of the days, on which the net-reeling was incapable on account of high sea, and calling the ratio $\frac{\text{the number of days in which the net-reeling was incapable}}{\text{the whole number of days of 0 day inserted in the table of 1926}} \times 100$ the rate of net-reeling (K), we obtain the curve as illustrated in Fig. III. The curve in Fig. IV, which was drawn after the example of Table II by selecting the cases in which the net-reeling was capable throughout 7 days before and after 0 day, is proportional to the aggregation-curve[1] of the shoal of "*Buri*."

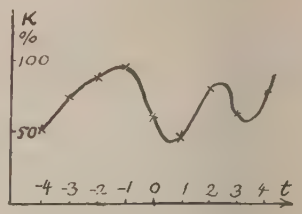


Fig. III.

If we calculate KN by combining Fig. III with Fig. IV, we get a curve shown in Fig. V B which runs in a tolerably nice parallelism with the curve of the actual catch (Fig. V A).

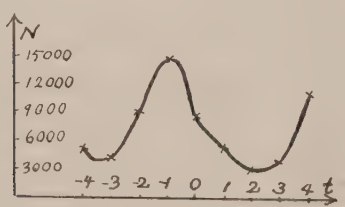


Fig. IV.

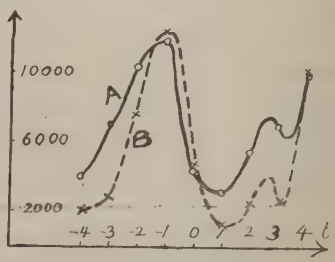


Fig. V.

1) By aggregation-curve the author means the curve which respresents the mode of the variation of the number of "*Buri*" aggregated at the fishing station in the bay before and after 0 day.

Here it is noticeable that Fig. III and Fig. IV, accordingly Fig. VB, show the influence belonging to a cyclone in the range of 5 days about 0 day. Thus, it may be seen that at least according to the material in 1926, the idea above mentioned is correct and agrees with the actual case. That is to say, the state of aggregation of the shoals of "*Buri*" is represented by the curve which has the maximum at −0.5 day, and that maximum implies that the waves along the sea-bottom of long wave-length caused by the cyclonic disturbance reaches the bay before the arrival of that cyclone and stirs up the water. Thus, as the result of stirring, the turbidity of water in the bay increases and the shoals of "*Buri*" are enticed. In short the higher the sea, i.e. the more conspicuous the turbidity, the more the shoals of "*Buri*" are induced. Hence, the author considers that the inventions and improvements of the fishing-implements as well as of the methods of fishing which may stand against the violence of rough sea are very desirable. Further, the aggregation-curve of the shoal of "*Buri*" shows us that the ascending slope of the curve is less than the descending. In other words, the rate of increase of the number of aggregation of the shoals of "*Buri*" differs from that of its decrease. This fact may be interpreted in the following lines: the shoals of "*Buri*" are induced in the bay and aggregated at the fishing station by the excitation of the rough sea. Moreover it may be considered that the degree of sensitivity of "*Buri*" to the excitation such as that due to the rough sea caused by cyclone in the fishing season i.e. the rate of aggregation is subjected to the law of probability function. Thus, the number of the fish in the bay at time t (,where t=0 corresponds to the time when the entrance of the fish began,) may be put $\int_o^t \frac{dN}{dt}\,dt = \int_o^t Ae^{-h^2t^2}\,dt$ and the number remaining at t after the exit of the fish has begun at $t=0$ may be put $N_o - \int_o^t Be^{-h'^2t^2}\,dt$, where A, B, h and h' are characteristic constants and N_0, the maximum number of the fish entered in the bay. Hence, the fact that the ascending slope and the descending one differ from each other may be supposed to be brought about on account of the difference of the probability-curves for the two cases.

Next, we investigated the mode of the rise and fall of the curves of the monthly catches for every year throughout 9 years and found a remarkable similarity of form between this curve and that of Fig. IV. In this case, however, the aggregation and dispersion of the shoals of "*Buri*" in the fishing season are considered to be connected with the variation in the mean temperature of sea water, instead of the approach of cyclone as in the preceding case.

A further discussion on this interesting problem is to be reserved for a future investigation. Returning to our principal result (Fig. I), it occurred to the author to investigate whether a similar relation as in the case of "*Buri*" may hold or not for the other fishes, that is to say, "*Iwasi*" (*clupea melanosticta* Schlegel) and "*Saba*" (*Scomber Japonicus Houttuyn*). The records available for this purpose are those at Nisimura Fishing Station, 1925 & 1926, obtained with the net, *Ôsikiami*. For the purpose of comparison the records at the Ogusi Fishing Station situated near that of Nisimura were also employed. Those results are given in Table IV & Fig. VI (in 1926 at Nisimura Station), Table V & Fig. VII (in 1925 at Nisimura Station), and Table VI & Fig. VIII (in 1925 at Ogusi Station), where the curve I marked with (---×---) indicates the catch-curve (N') for "*Buri*," and II (——o——) that for "*Iwasi*" and III (—·—△—·—), for "*Saba*."

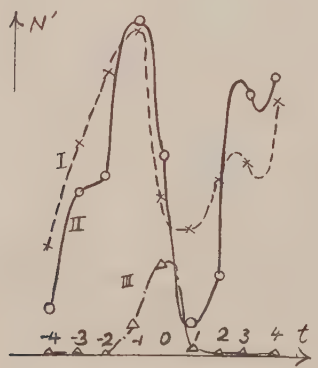


Fig. VI.

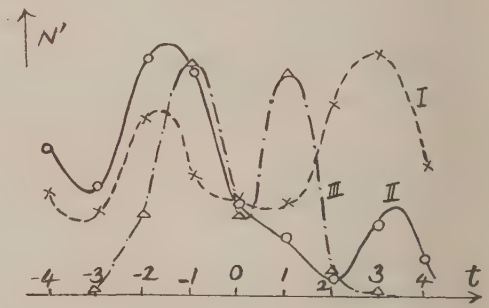


Fig. VII.

Table IV.

Name of Fish \ day	−4	−3	−2	−1	0	1	2	3	4
Buri	7792	14196	20688	23844	9021	6532	11274	13610	20044
Iwasi	259	932	1025	2059	1125	155	818	1547	1588
Saba	0	0	0	214	642	4	0	0	0

Table V.

Name of Fish \ day	−4	−3	−2	−1	0	1	2	3	4
Buri	16020	15405	25837	19378	16338	16105	26801	32645	28869
Iwasi	3552	2650	4387	4147	2365	1628	656	1858	1134
Saba	0	0	1617	4850	1619	4868	54	0	0

TABLE VI.

Name of Fish \ day	−4	−3	−2	−1	0	1	2	3	4
Buri	17191	7149	794	10729	3133	983	118	21856	14106
Iwasi	346	634	174	266	302	101	265	417	431
Saba	11985	6565	7279	2565	7937	20475	12121	6101	20668

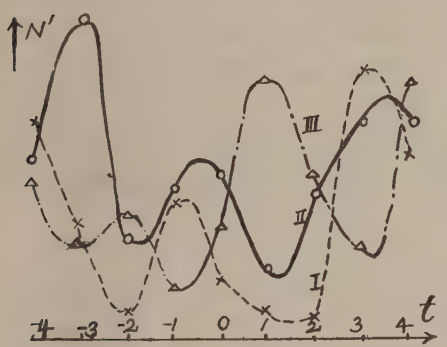


Fig. VIII.

From the curves we notice that N' for "*Iwasi*" varies in the same manner as that of "*Buri*" with respect to the approach of cyclone. On the contrary N' for "*Saba*" represents a variation inverse to that of "*Buri.*" The latter seems to agree with the empirical fact known to the fishermen of *Kôti* Prefecture in Sikoku (a district distant from Nagasaki Prefecture) that the more the catch of "*Buri,*" the less the catch of "*Saba*" by the same Taibôami (a kind of pound net), and vice versa. This corresponds to the general belief that on one hand, the more the sea water turns turbid, the more rich the catches of "*Buri*" and "*Iwasi*" are expected, and, on the other hand, the more clear the sea water, the more rich the catch of "*Saba*" is expected. These problems will have certain relations with the habits and foods of those fishes and with the temperature of sea water in which they live; they should be discussed in future studies.

In conclusion the author wishes to express his cordial thanks to Dr. M. Tauti for his kind guidance during this research, to Dr. T. Terada for his instructions and advices.

Abstract.

1. From a statistical study of the records of the catch during 9 years at Nisimura Fishing Station in Nagasaki Prefecture the author deduced the state of distribution of the catch of "*Buri*" over several days before and after the day on which (−) (+)
the centre of a cyclone was located nearest to that station (say 0 day).

A maximum of the catch-curve corresponding to so called "*Maeryô.*" (Pre-fishing) appears at −1.5 day, and a minimum of the catch-curve exists at +.5 day.

It has also been found that the position of the maximum corresponding to so called "*Atoryô*" (Post-fishing) lies at +2.5 day.

2. The idea that the catch-curve is the consequence of a combination of the aggregation-curve of the shoal of the fish and the curve of the rate of net-reeling was proposed. It has been ascertained by the only records in 1926, the only material available. Hence it is considered that the more violent the sea rages, the more abundantly the shoals of "*Buri*" enter into the bay.

3. The unit of the shoals of "*Buri*" is probably that of the order of 1000.

4. Comparing the aggregation-curve of the shoals of the fish connected with the approach of a cyclone with the one connected with the mean temperature of sea water, the characteristics of the curve were discussed.

5. The same results as obtained for "*Buri*" were obtained for "*Iwasi.*"

6. A contrary variation of the catch-curve associated with the approach of cyclone was observed in the case of "*Saba.*"

September, 1927. Physical Laboratory, Imp. Fisher. Inst. Tokyô.

STUDIES OF NETTING CORDS II.

RELATION BETWEEN THE LOAD AND THE ELONGATION OF NETTING CORDS.

By

Dr. M. Tauti.

It may be easily considered that the relation between the load and the elongation of a soft twisted cord (like the netting cotton cord) caused by the weight of the load can have an aspect a little different from the relation deduced from the ordinary theory held on a simple elastic body.

With a view to ascertain the relation between the load and the elongation of the netting cord, and furthermore to bring the mechanism of the elongation of the netting cord to light, I troubled 13 students (divided to 6 sets of observer) of the Fishing Course of our institute to take the part of our experiment on the 3-ply-cotton-cord of which each thread is composed of 6 $20^{/s}$ yarns ($\nu=6$).

The method of expreiment is very simple, and the outline of the apparatus used

is illustrated in Fig. 1. The netting cord (1) under test was stretched to a certain extent and then two marks (2) having the distance of 30 cm were put on it. Then the cord was hanged down, the one end of which being tied to the hook (3) and the other to the counter-weight (4). In this state the distance between (2) and (2) being measured by means of the scale (5) which is put vertically behind the cord, we got its elongation after an hour for each counter-weight. In order to avoid the untwisting of the cord, we loosely connected the adjacent counter-weights by means of a thin soft wire (6).

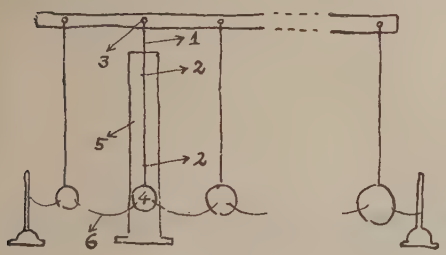


Fig. 1.

TABLE I.

Apparent elongation $\Delta l'_{cm.}$

Load Wkg.										Number of times of observation	Observer
0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0		
3.34	4.44	5.24	5.80	6.27	6.68	7.04	7.26	7.52	7.78	10	S. Takeda, S. Turuta.
3.52	4.42	5.09	5.52	5.94	6.45	6.77	7.13	7.37	7.59	10	T. Iyama, M. Ueda.
3.49	4.69	5.54	6.22	6.60	7.02	7.28	7.63	7.96	8.12	10	G. Tutumi, K. Nakamura.
3.72	4.78	5.79	6.38	6.82	7.27	7.52	7.78	8.00	8.16	10	C. Y. Moo, W. F. Ching.
3.42	4.27	5.15	5.63	6.28	6.69	7.06	7.37	7.58	7.65	10	T. Seto, M. Morita, N. Kondô.
3.56	4.58	5.41	6.10	6.55	6.98	7.23	7.55	7.75	7.96	10	M. Esaki, M. Kokubo.
3.51	4.53	5.37	5.94	6.41	6.85	7.15	7.45	7.70	7.88		

Table I indicates the results.

Since a twisted thread, being in its free state, increases its size as the consequence of loosening and contracts its length, it is remarkably elongated by very slight load as the result of tightening when it is stretched. Therefore we can reasonably consider that the true elongation of the twisted thread caused by the load takes place after such a loosening having been tightened to a certain extent. But, since we can not easily decide the degree of the tightening in which the elongation caused by the load begins, we will take the length of the cord stretched to a certain extent as its initial length. Accordingly the initial length l_o' (in our case 30 cm.) differes from the length l_o measured in the condition under which the elongation due to the load begins, and the difference e between l_o and l_o' differs in each

observer. Since the elongation after an hour due to a constant load is considered as proportional to l_o, the full length after an hour becomes $(1+\delta)l_o$ viz. $(l_o'+e)(1+\delta)$, where δ denotes the rate of elongation due to the load. And since the apparent elongation $\Delta l'$ is the difference between the full length after an hour and the initial length,

$$\Delta l' = (l_o'+e)(1+\delta) - l_o'$$
$$\fallingdotseq l_o'\delta + e$$
$$\therefore \frac{\Delta l'}{l_o'} \fallingdotseq \delta + \frac{e}{l_o'}.$$

Accordingly, let the ratio of the apparent elongation to the initial length, or in other words, the rate of apparent elongation be δ',

$$\delta' = \frac{\Delta l'}{l_o'} \fallingdotseq \delta + \frac{e}{l_o'}.$$

As e does not depend upon the load, the difference in the values of δ' obtained by the observers of the six sets is independent of the load. This can be easily seen from Table I. Consequently we can discuss the relation between the load and the elongation by using the mean value of δ' which was obtained by the observers of the six sets.

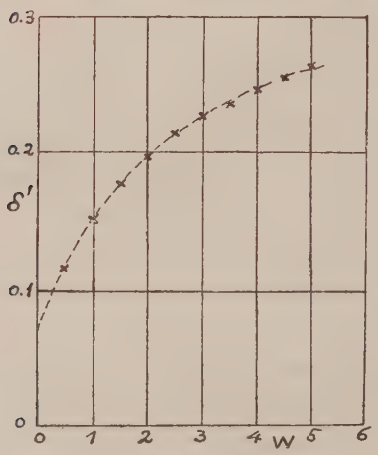


Fig. 2.

The apparent rate of elongation δ' calculated from the mean value given in Table I is shown in Table II. Fig. 2 gives us the relation between δ' and the load W, and it shows that $\delta'-\delta$ is nearly equal to .070. Hence the rate of elongation due to the load δ is to be calculated approximately by the following expression,

$$\delta' - \delta = .070$$

If all the yarns of the 3-ply-cotton-cord of which each thread is composed of ν yarns can be taken as quite equal elements, it may be considered

TABLE II.

$W_{kg.}$	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
δ'	.117	.151	.179	.198	.214	.228	.238	.248	.257	.263
δ	.047	.081	.109	.128	.144	.158	.168	.178	.187	.193
$\delta_{cal.}$	.040	.075	.100	.122	.140	.154	.166	.175	.185	.190
$\log (1+\delta)\frac{d\delta}{dW}$		$\bar{2}.83$	$\bar{2}.72$	$\bar{2}.59$	$\bar{2}.53$	$\bar{2}.45$	$\bar{2}.36$	$\bar{2}.34$	$\bar{2}.26$	

that any one of those yarns coils around the other $(\nu-1)$ yarns, roughly in a common helical form. And the ν yarns of which each thread is composed are not firmly fathened by twisting, but contact lightly. Hence it may be supposed that when the thread is stretched out, the yarns come to be compressed and as its consequence the size of the thread is moderately contracted.

Now if we apply the load W *kg.* on the cord, the load participated on each yarn is $\frac{W}{3\nu}$ *kg.*; accordingly the tension of each yarn is $\frac{W}{3\nu}$ *kg.*

Since the yarn can be approximately considered to describe a common helix, the compressive force P produced by the tension $\frac{W}{3\nu}$ on the $(\nu-1)$ yarns is proportional to $\frac{r}{r^2+\frac{h^2}{4\pi^2}} \cdot \frac{W}{3\nu}$, where r and h denote the radius of the thread and the length of one twist respectively.

If we assume that the elongation of the yarn due to the load may be neglected, it is easily to be shown that $r^2+\frac{h^2}{4\pi^2}$ has always a constant value. Hence let the values of r and h in the condition under which the elongation due to the load begins to take place be r_o and h_o respectively,

then $$r^2+\frac{h^2}{4\pi^2}=r_o^2+\frac{h_o^2}{4\pi^2} \qquad \ldots\ldots(1)$$

Therefore $$P \propto \frac{r}{r_o^2+\frac{h_o^2}{4\pi^2}} \cdot \frac{W}{3\nu}.$$

If we assume that the radius of the thread varies from r to $r+dr$ according to the compressive force increases from P to P+dP, and that $-\frac{dr}{r}$ is proportional to dP, we have an expression (2) for the relation between r and W.

$$\frac{r}{r_o}=e^{-\frac{ar_o W}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)} \cdot \frac{r}{r_o}} \qquad \ldots\ldots(2)$$

where a denotes some constant depending upon the quality of the thread.

Calculating the values of $\frac{r}{r_o}$ from equation (2), we get the results given in Table III.

TABLE III.

$\frac{a \log e.\ r_o\ W}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}$	.1	.2	.3	.4	.5	.6	.7	.8
$\frac{r}{r_o}$	.83	.71	.65	.58	.54	.50	.47	.44
$\log\frac{r}{r_o}$	$\bar{1}.92$	$\bar{1}.85$	$\bar{1}.81$	$\bar{1}.76$	$\bar{1}.74$	$\bar{1}.70$	$\bar{1}.67$	$\bar{1}.64$

The relation between $\log\frac{r}{r_o}$ and $\frac{a \log e.\ r_o\ W}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}$ is roughly expressed by the next equation (2′), as shown in Fig. 3.

$$\frac{r}{r_o}=e^{-\frac{.48\ a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}\ W.} \qquad \ldots\ldots(2')$$

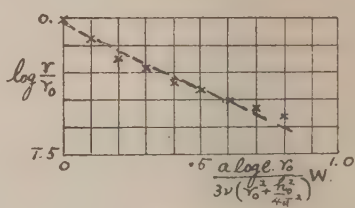


Fig. 3.

In the case when we apply the load in such a way that no variation occurs in the number of twist, it is evident that the equation (3) can be established between h, h_o and δ,

$$\frac{h}{h_o}=1+\delta. \qquad \ldots\ldots(3)$$

Substituting (2′) and (3) in (1), we have

$$(1+\delta)^2-1=\frac{4\pi^2 r_o^2}{h_o^2}\left\{1-e^{-\frac{2\times.48\ a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}\ W}\right\}. \qquad \ldots\ldots(4)$$

The rate of elongation due to the load is given by (4) approximately.

Differentiating the both sides of the equation (4) with respect to W and taking their logarithm, we have equation (4′)

$$\log\left[(1+\delta)\frac{d\delta}{dW}\right]=\log\left[\frac{4\pi^2 r_o^2}{h_o^2}\times.48\frac{a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}\right]-2\log e\times\frac{.48\ a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}W \ldots(4)'$$

The equation (4′) shows that $\log\left[(1+\delta)\frac{d\delta}{dW}\right]$ and W should be connected with a rectilinear relation.

Then evaluating $\log\left[(1+\delta)\frac{d\delta}{dW}\right]$ from the values of δ obtained previously, we get the results as given in Table II. Fig. 4 shows the relation between $\log\left[(1+\delta)\frac{d\delta}{dW}\right]$ and W.

Looking at Fig. 4 we can notice that the equation (4′) is established correctly and in this case we have

$$\log\left[4\pi^2\frac{r_o^2}{h_o^2}\times\frac{.48\ a\ r_o}{3^\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}\right]=\bar{2}.97; \qquad 2\log e\frac{.48\ a\ r_o}{3^\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}=.164$$

$$4\pi^2\frac{r_o^2}{h_o^2}\times\frac{.48\ a\ r_o}{3^\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}=.093; \qquad \frac{.48\ a\ r_o}{3^\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}=.189$$

$$4\pi^2\frac{r_o^2}{h_o^2}=.49$$

$$\frac{r_o}{h_o}=.112$$

Hence in the case when $\nu=6$, the value of δ can be represented by the folllowing equation (5)

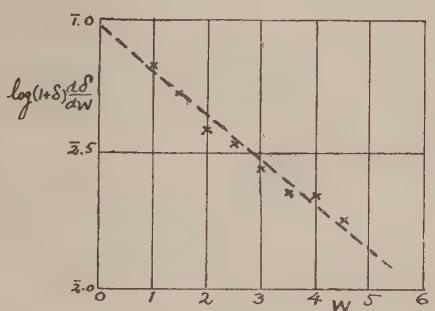


Fig. 4.

$$(1+\delta)^2-1=.49\left(1-10^{-.164W}\right) \quad \ldots\ldots(5)$$

δ_{cal} inserted in Table II means the value of δ evaluated from the equation (5). And we can easily ascertain from the same Table that δ_{cal} pretty well coincides with the measured value of δ.

The relation among r_o' and h_o' (the radius of thread and the length of one twist of thread when the cord is stretched to a certain extent), and r_o and h_o (the radius of thread and the length of one twist of thread when the elongation due to the load begins to take place), is represented by the equation (1),

$$r_o^2+\frac{h_o^2}{4\pi^2}=r_o'^2+\frac{h_o'^2}{4\pi^2}$$

namely $$\frac{h_o^2}{h_o'^2}\left(\frac{1}{4\pi^2}+\frac{r_o^2}{h_o^2}\right)=\frac{1}{4\pi^2}+\frac{r_o'^2}{h_o'^2}.$$

As previously mentioned,

$$\frac{h}{h_o'}=1+\delta', \quad \frac{h}{h_o}=1+\delta, \quad \delta'-\delta=.070,$$

we have $$\frac{h_o}{h_o'}\fallingdotseq 1.070$$

And moreover $$\frac{r_o}{h_o}=.112$$ as obtained from Fig. 4.

Hence substituting those values in the above equation and calculating the value of $\frac{r_o'}{h_o'}$, we get

$$\frac{r_o'}{h_o'}=\mathbf{.134}$$

To a certain extent stretching the thread composed of 6 20′′ yarns and measuring the diameter and the number of twists in the length of 30 cm. we obtained the following average values.

$2r_o'=.50$ mm. number of twist of the cord (upper twist)$=68$

„ „ „ of the thread (lower twist)$=240$

It may be calculated as follows

$$h_o'=\frac{300}{240-68}=1.85 \text{ mm.}$$

Calculating $\frac{r_o'}{h_o'}$ from the values of r_o' and h_o' thus obtained, we have

$$\frac{r_o'}{h_o'}=\mathbf{.135}$$

Such a nice coincidence of the measured value of $\frac{r_o'}{h_o'}$ with the calculated value approves that the theory on the elongation of the twisted thread due to the load is correct.

Formerly, I discussed on the weakening of the strength of netting cords in water. In that paper,[1] considering that when $\nu \leqq 8$, all the yarns constructing the cord are

1) M. Tauti, J. Imper. Fish. Inst. XXII. (1927).

equally exposed upon the surface of the cord and that the unexposed yarns increases as ν, I deduced the relation between the rate of weakening of the cord in water and the size of cord, and showed that the relation agrees well with the experimental results.

Thus, if all the yarns can not be taken as quite equal elements when $\nu > 8$, in our present problem also, it may be considered that the theory above mentioned becomes more unsuitable according as ν increases.

However, in the case of the weakening, it should be discussed on the comparatively short portion of the cord. But, in the case of the elongation it should be discussed on the comparatively long portion. Therefore in the former case we can distinguish the yarns exposed on the surface from the yarns unexposed when $\nu > 8$; but in the latter case, it seems to be difficult to make a difference between the exposed

TABLE IV.

	W kg.	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	
$\nu=8$	$\Delta l'_{cm.}$	3.08	3.87	4.57	4.98	5.48	5.91	6.13	6.43	6.58	6.90	7.11	7.24	
	$\delta'=\frac{\Delta l'}{30}$	.103	.129	.152	.166	.183	.197	.204	.214	.219	.230	.237	.241	
	$\delta=\delta'-.070$	.033	.059	.082	.096	.113	.127	.134	.144	.149	.160	.167	.171	
	$\log(1+\delta)\frac{d\delta}{dW}$		$\bar{2}.72$	$\bar{2}.60$	$\bar{2}.53$	$\bar{2}.54$	$\bar{2}.38$	$\bar{2}.29$	$\bar{2}.24$	$\bar{2}.27$	$\bar{2}.32$	$\bar{2}.11$		
	W kg.	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0		
$\nu=12$	$\Delta l'_{cm.}$	2.76	3.52	3.94	4.29	4.74	5.00	5.40	5.62	5.65	5.92	6.21		
	$\delta'=\frac{\Delta l'}{30}$	.092	.117	.131	.143	.158	.167	.180	.187	.188	.197	.207		
	$\delta=\delta'-.066$	.026	.051	.065	.077	.092	.101	.114	.121	.122	.131	.141		
	$\log(1+\delta)\frac{d\delta}{dW}$		$\bar{2}.31$	$\bar{2}.14$	$\bar{2}.16$	$\bar{2}.12$	$\bar{2}.08$	$\bar{2}.05$	$\bar{3}.65$	$\bar{3}.75$	$\bar{2}.03$			
	W kg.	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
$\nu=20$	$\Delta l_{cm.}$	2.63	3.19	3.69	3.95	4.46	4.71	4.91	5.19	5.31	5.67	6.00	5.92	6.37	6.37	6.63
	$\delta'=\frac{\Delta l'}{30}$	.088	.106	.123	.132	.149	.157	.167	.173	.177	.189	.200	.197	.212	.212	.221
	$\delta=\delta'-.065$	.023	.041	.058	.067	.084	.092	.099	.108	.112	.124	.135	.132	.147	.147	.156
	$\log(1+\delta)\frac{d\delta}{dW}$		$\bar{2}.27$	$\bar{2}.14$	$\bar{2}.14$	$\bar{2}.13$	$\bar{3}.91$	$\bar{3}.94$	$\bar{3}.86$	$\bar{3}.95$	$\bar{2}.11$	$\bar{3}.66$	$\bar{3}.83$	$\bar{3}.94$	$\bar{3}.71$	
	W kg.	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0		
$\nu=30$	$\Delta l'_{cm.}$	3.60	4.18	4.63	5.08	5.23	5.29	5.85	5.89	6.24	6.41	6.37		
	$\delta'=\frac{\Delta l'}{30}$	.120	.139	.154	.169	.174	.176	.195	.196	.208	.214	.212		
	$\delta=\delta'-.100$	.020	.039	.054	.069	.074	.076	.095	.096	.108	.114	.112		
	$\log(1+\delta)\frac{d\delta}{dW}$		$\bar{3}.95$	$\bar{3}.90$	$\bar{3}.73$	$\bar{3}.28$	$\bar{3}.75$	$\bar{3}.74$	$\bar{3}.55$	$\bar{3}.70$	$\bar{3}.05$			

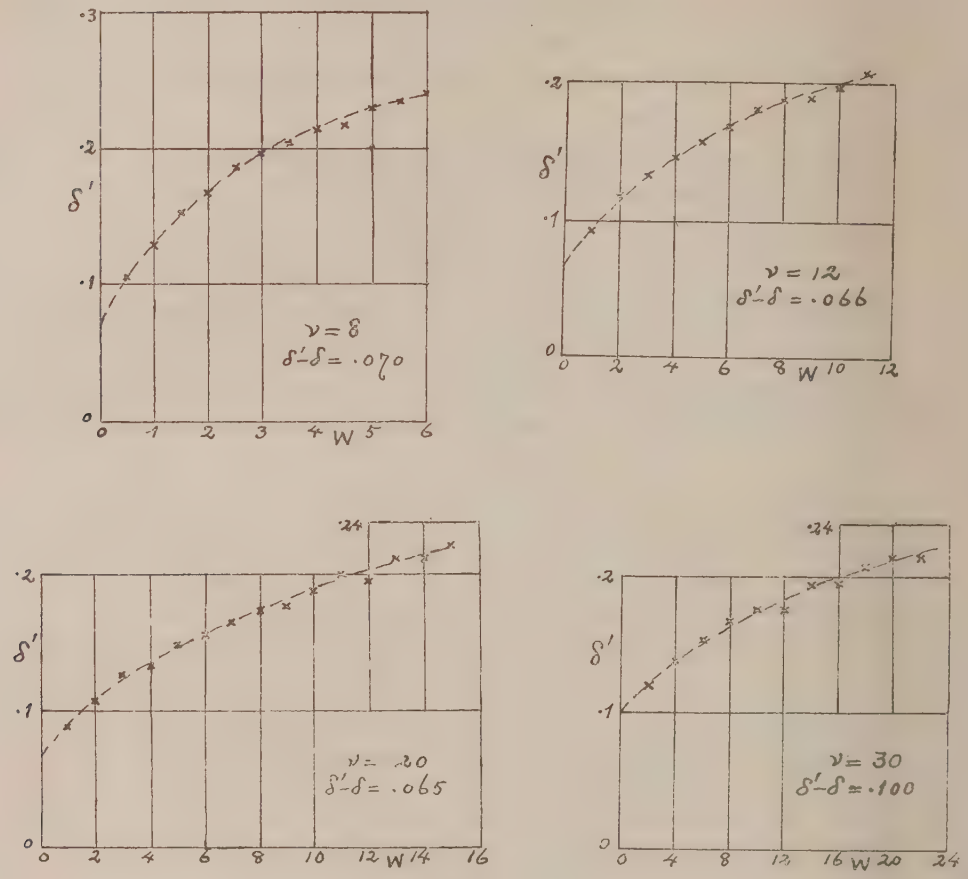


Fig. 5.

and the unexposed yarns as they are entangled to each other in the comparatively long portion. Hence it may be considered that the theory above stated is always consistent notwithstanding the size of the cord.

To make an assurance on this point, I have repeated the same experiment as before by the help of Messrs K. Miyosi and H. Kanenobu on the 3-ply-cotton-cord, of which each thread is composed of 8, 12, 20 and 30 20's yarns (ν=8, 12, 20 and 30).

The average values of $\Delta l'$ and δ' obtained from the measured values of the elongation of the cord after an hour for constant weight are given in Table IV.

Fig. 5 shows the relation between δ and W.

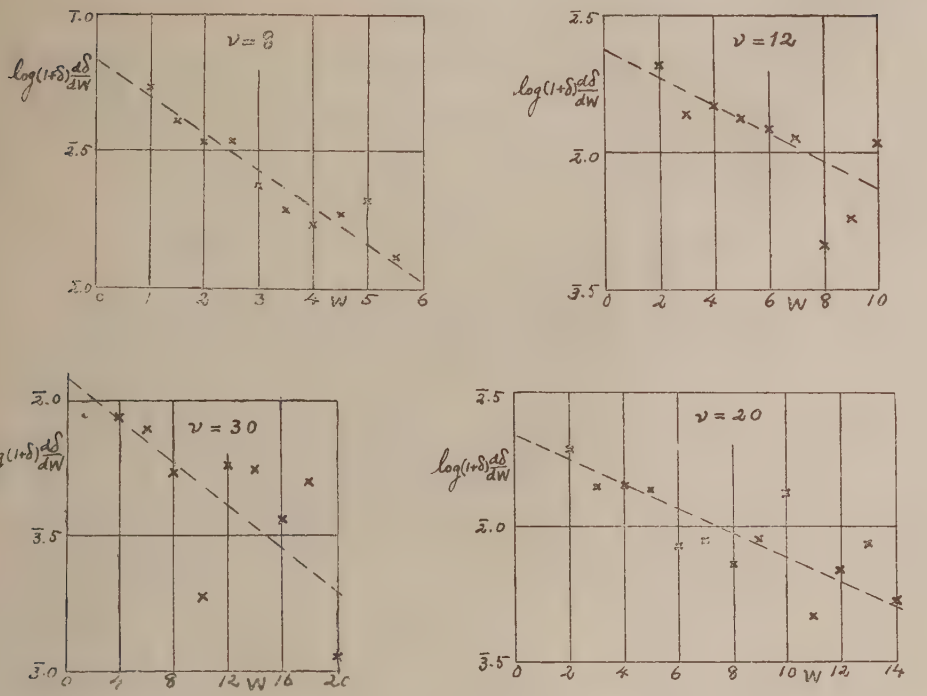


Fig. 6.

We can see from this figure that when the values of ν are 8, 12, 20 and 30, the values of $\delta' - \delta$ are .070, .066, .065 and .100 respectively.

The values of δ calculated from δ' and $\log\left[(1+\delta)\frac{d\delta}{dW}\right]$ are given in Table IV.

W and $\log\left[(1+\delta)\frac{d\delta}{dW}\right]$ are connected with a rectilinear relation for every cord as seen in Fig. 6. The broken line in Fig. 6 shows an approximate relation between $\log\left[(1+\delta)\frac{d\delta}{dW}\right]$ and W.

Determining $\log\left[4\pi^2\frac{r_o^2}{h_o^2} \times \frac{.48\ a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}\right]$ and $2\log e \times \frac{.48\ a\ r_o}{3\nu\left(r_o^2 \times \frac{h_o^2}{4\pi^2}\right)}$ from those broken lines, and further calculating $4\pi^2\frac{r_o^2}{h_o^2}$, $\frac{r_o}{h_o}$ and $\frac{r_o'}{h_o'}$, we have the results given in Table V.

TABLE V.

ν	8	12	20	30
$\log\left[4\pi^2\frac{r_o^2}{h_o^2}\times\frac{.48\ a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}\right]$	$\bar{2}.84$	$\bar{2}.38$	$\bar{2}.33$	$\bar{2}.08$
$2\log c\times\frac{.48\ a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}$	.136	.052	.045	.039
$\left[4\pi^2\frac{r_o^2}{h_o^2}\times\frac{.48\ a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}\right]$	.069	.024	$.021_4$	$.012_0$
$\frac{.48\ a\ r_o}{3\nu\left(r_o^2+\frac{h_o^2}{4\pi^2}\right)}$	.157	.060	.052	.045
$4\pi^2\frac{r_o^2}{h_o^2}$	.44	.40	.41	.27
$\frac{r_o}{h_o}$	.106	.100	.102	.082
$\frac{r_o'}{h_o'}$	**.128**	**.127**	**.123**	**.116**

And measuring the diameter and the number of twist in the length of *30 cm.* of the thread which was stretched to a certain extent, and evaluating $\frac{r_o'}{h_o'}$ from those mean values by the same method of calculation as before, we get the results as indicated in Table VI.

TABLE VI.

Number of yarns composing each thread ν		8	12	20	30
Diameter of thread	$2r_o'$	.63	.80	.99	1.19
Number of twist of cord (upper twist) in *30 cm.*		66.9	64.0	52.0	41.2
,, ,, ,, ,, thread (lower twist)	,,	209.3	148.0	134.0	101.8
Length of one twist of thread	h_o'	2.10	3.57	3.65	4.95
	$\frac{r_o'}{h_o'}$	**.150**	**.112**	**.136**	**.120**

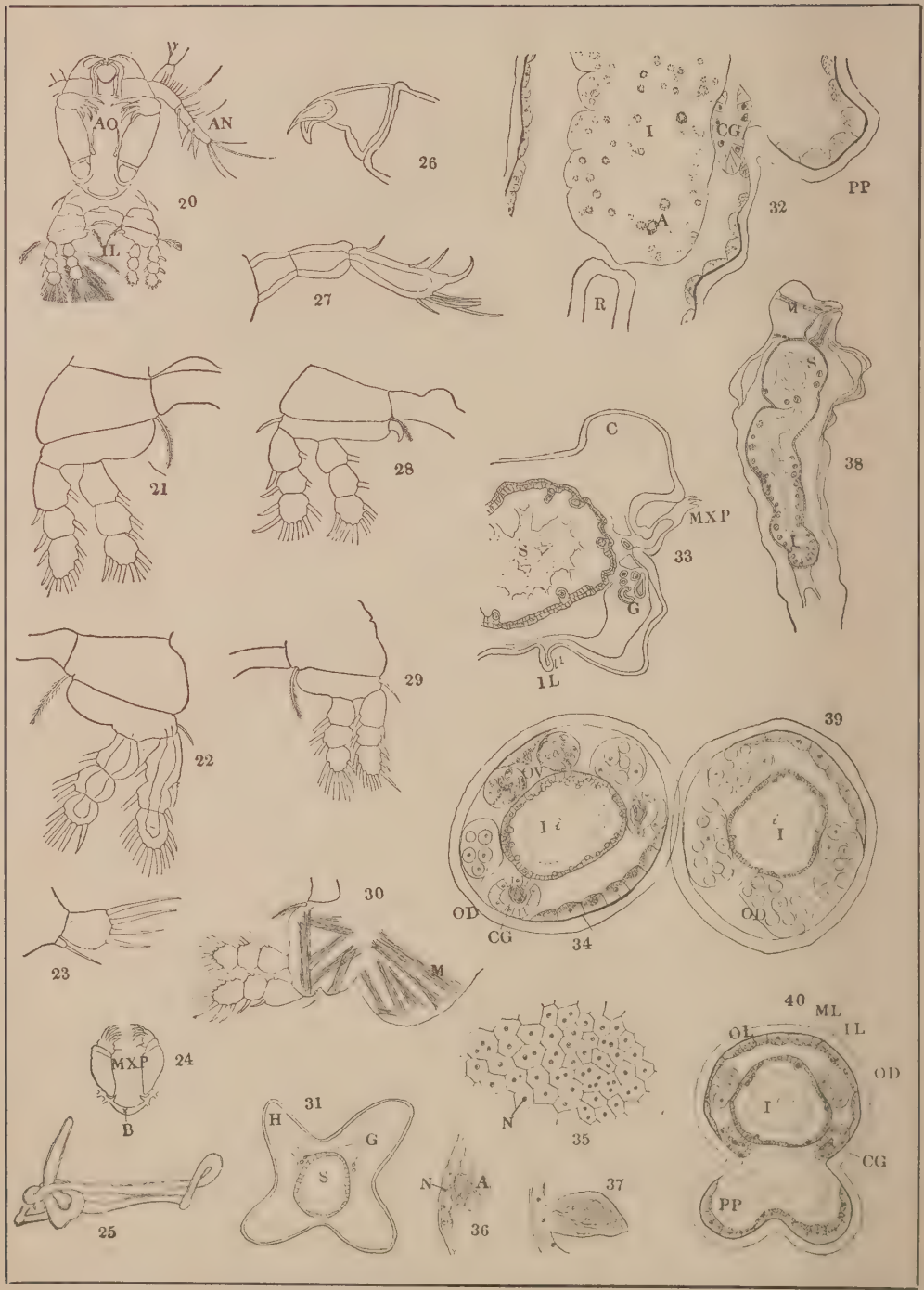
Comparing the values $\frac{r_o'}{h_o'}$ given in Table V with those in Table VI, we can

see that the value of $\frac{r_o'}{h_o'}$ deduced from the above theory of the elongation coincides pretty well with the value obtained from the direct measurement.

Hence we see that, inspite of the size of the cord, this theory can be applied and also that, in the case when we consider of the elongation, all the yarns constructing the cord can be taken as quite equal elements.

In conclusion, I wish to express my vest thanks to Dr. T. Terada for his valuable advices.

Oct., 1927. Physical laboratory, Imp. Fisher. Institute, Tôkyô.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Del. Kumada.

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Del. Kumada.

Dr. Leigh-Sharpe and our friend Mr. Seizo Takeda. Our thanks are also due to Prof. Chiyomatsu Ishikawa for his kindness in looking over our manuscript.

This parasite is found in the buccal cavity and rarely on the skin of the eel (*Anguilla japonica*) and also lives as an ectoparasite among the scales of *Cyprinus carpio* L., *Carassius auratus* (L.), *Pseudorasbora anguillicaudata* (Canter), *Plecoglossus altivelis* T & S., *Oryzias latipes* T. & S. and *Pseudorasbora parva* (T. & S.).

Eels that are infected by this parasite show bloodish marks on the ventral part of the lower jaw, both upper and lower jaws shrink to a crooked form, and the head takes particular shape (Pl. V. fig. 1. A and D), the mouth is half open and we can observe externally the parasites clinging in cluster to the buccal cavity.

Analytical observation reveals that the liver is congested, gall-bladder discolored and swollen, digestive organ emptied and blood vessels of the wall of the body cavity conspicuously congested.

Morphology.

1. Body: In adult female it is measured 12 m.m. from the top of head to the end of egg sac. Second and third thoracic-segments slender, fourth and fifth segments plump and take boot-like shape together with pregenital prominence. In third segment, it has torsion of 90 degrees direct or inverse to longitudinal axis.

2. Head: Head is hemispherical and protrudes further than the plane formed by horns. Eyes are situated under skin in the posterior summit of it. First antenna is four-jointed and has numerous plumose setae at anterior margin of each joint, having specially longer ones on terminal joint. Second antenna is three-jointed, having three setae at inner margin of terminal joint, five plumose setae at outer margin and tipped with a claw like spine. Mandible is very small and hard to observe. First maxilla is situated posterior to second maxilla. Maxilliped is slightly long and plump and is composed of distal joint having two mammillated prominences at internal end, terminal joint having movable five claw like spines. Although Dr. Leigh-Sharpe describes "Auricular expansion" and thoracic appendage, we did only observe arch-shaped bandage connecting each basal joint of both maxillipeds. (Fig. 23.)

3. Horns: Ring-shaped conspicuous boarder line is observed between head and horns and its shape is like letter X. According to the age of worms, form of horn varies much, at younger stage it takes the form (Fig. 1.)

4. Swimming legs: In the centre of anterior prominence of horn, first swimming leg is to be observed. Second and third swimming legs attach to ventral side at the

posterior edge of swollen part of body segment. Fifth swimming leg is situated at the posterior end of thoracic segment right in front of vulva. (Fig. 20, 21, 23, 27, 28.)

5. Pregenital prominence: A buttock like prominence exists on ventral side of posterior end of fifth thoracic segment, its degree of development varies according to age.

6. Genital segment: Genital segment of young with body length of 4 mm. is 0.175 mm. long, 0.123 mm. wide, and is largest of all abdominal segments, but in adult it fuses together with first abdominal segment, leaving no boarder line between two. (Fig. 14, 15.)

7. Abdomen: Four segmented in young, but in adult first and third segments fuse together forming three segments with genital and fourth segment. The anal lamina is formed of three parts. First part is swollen having three setae, middle part is cylindrical and last is needle like and plumose. (Figs. 14, 15.)

8. Skin: Skin consists of three layers, outer is thick and chitinous. Middle layer is very thin, while inner layer is formed of a single layer of multinucleated cells and pavement like. This layer is well developed in posterior-part of body, in middle part it exists only in dorsal and abdominal, while none in anterior part. (Figs. 33, 34, 39.) Skin has numerous funnel shaped pore canals, which are more numerous in posterior half of body. (Figs. 2, 3, 4.)

9. Alimentary canal: Mouth is situated at ventro-anterior end of cephalic segment forming snout. Phalynx comes next to mouth. Oesophagus is short and slender, and passes directly to large stomach. Its connection with intestine takes place within body at level of first swimming leg. Intestine has few large constrictions in anterior portion, but proceeds as straight tube marked by mumerous ring-like constrictions and extends to boarder line of thorax and abdomen, whence it proceeds directly as rectum. Alimentary canal is composed of outer and inner layers, the former is thin and muscular, while the latter consists of a layer of rather large epithelial cells with numerous vacuoles containing green chlorophyll granules, the size of which varies very much. Regarding this granules, Leuckart, Wagner and Reinicke have already described their existence in epithelial cells of intestine of Europian species and Hartman thinks that these may be "Prosospermum", but no definite opinion is established for their real nature. Leigh Sharpe proposed that they would be a symbiotic alga and named them as *Cassationvolvox copepodicola*, to which we wish to express our agreement, regarding various forms of granules due to different stages of this symbiotic alga. (Figs. 31, 35.)

One pair of gland exists on both sides of stomach.

10. Muscular system: In adult, well developed muscules are observed within cephalic and thoracic appendages, around vulva, anus and base of anal lamina, but none in other parts. In immature animals, muscules are seen in addition to above in thoracic and abdominal segments also.

11. Nerve system: Well developed nerves are seen to exist in immature stage, but they degenerate in adult. In adult form, nerves from supra-and suboesophageal ganglia to eyes are only present.

12. Reproductive organs: Reproductive organ in female is of the same type as in *Lernaea variabilis*, one end of ovary being connected to the wall of body cavity by means of a muscule. Oogonia-cells are present in the anterior part of ovary, whence eggs assume a chain of coin-shaped cells. Cement gland is composed of tube of swollen cells which are muscular in nature and contains a secrete cells. The secrete cell consists of bee-hive-shaped gland and is situated at the centre in the tube. Vulva is elliptical and a little prominent resembling to human ear-shell. (Figs. 14, 17.) Ovisac generally takes the shape of banana and in case of first impregnation it possesses about 20 eggs in one sac but from 270 to 300 eggs in well matured one. Egg is round or oval in shape and its size is 0.106 μ in long and 0.06 μ in short-diameter.

Development.

From well matured ovisacs nauplius hatches out. (Fig. 9.) It is elliptical, width being 0.14 mm, with length of 1.2–1.5 times of it.

First antenna is two-segmented having one spine at interior end of basal segment. Terminal joint has two plumose setae at its end and a short seta at inner margin. Second antenna has two appendages, exo-and-endopodites on basal segment. Exopodite is four-jointed and its terminal joint with a long plumose seta in centre, and short spines on both sides. One spine exists at the outer margin of other three joints. Endopodite is single-jointed, having two plumose setae at its anterior end and one spine at its inner margin. First maxilliped has four joints, its exopodite having one plumose seta at inner margin of basal joint, while single jointed endpodite having two plumose setae at its margin.

Balancer is comparatively short and is located closely to the both side of median line. (Fig. 9.)

In artificial culture conducted by the writers, nauplius has developed into metanauplius on twenty second day at 9°–13°C. Compound eyes are placed on median line close to anterior margin. (Text fig. 2, D.)

We could not observe copepod-larva by means of culture, but could find many larvae having incompletely developed horn from body of host. (Figs. 10–18.)

Lernaea elegans does not prosper in ponds of high salinity, and in examining 42 fish-rearing-ponds in consideration of relation between habitation of parasite and salinity along coast of the lake Hamana, Shizuoka prefecture, during September 1924, we have found parasites in 20 ponds whose salinity ranged between 0.0709–1.6965‰ NaCl. In 6 ponds whose salinity was found to range between 1.7889 to 7.7805‰ NaCl no parasites were observed, even though these ponds are exposed provably of infectious nature. This agrees to a large extent with result of our experiments which were carried out during last few years as regard to influence of salinity upon this parasite, and which we hope to publish before long in connection with exterminating experiments, but since the increase of salinity is the easiest method for its extermination, so we hope that this short note will prove in advance to be of some use to those who are suffering from this disease.

December, 1926.

Explanation of Plates.

Plate V.

Fig. 1. A & D. Head of *Anguilla japonica* acted upon by *Lernaea elegans.*
B. Buccal cavity of the same.
C. Head of healthy eel.

Fig. 41. Several stages of the nauplius cultured after the hatching at Nov. 5th, 1926. (Viewed from the dorsal).
A. Photographed on November 8, 1926.
B. „ on 7 days after.
C. „ on 10 „ „
D. „ on 18 „ „

Plate VI.

Fig. 2. *Lernaea elgans* Leigh-Shape. H. horn, C. cephalon, PP. pregenital prominence, AL. anal laminae, ES. egg sac, 1–5. 1st.–5th. swimming legs, × 6.

Figs. 3–5. Pore canal. 4L. 4th. swimming leg. × 35–200.

Fig. 6. A part of ovary and oviduct. × 50.
Fig. 7. Original part of ovary. × 75.
Fig. 8. Chain of coin-shaped cells in ovary. N. nucleus, × 300.
Fig. 9. Egg in ovary. × 300.
Fig. 10. Nauplius. × 140.
Figs. 11, 12, 13, 17. Young stage. × 25.
Fig. 14. Mouth part. × 75.
Figs. 15, 16. Abdomen of young one. V. vulva, × 100.
Fig. 18. Abdomen of Fig. 17. 5L. 5th. swimming leg, V. vulva. × 100.
Fig. 19. Young stage. × 6.

Plate VII.

Fig. 20. Cephalothorax. AO. around mouth, AN. antenna, 1L. 1st. swimming leg × 140.
Fig. 21. Second swimming leg. × 300.
Fig. 22. Fouth swimming leg. × 300.
Fig. 23. Fifth swimming leg. × 300.
Fig. 24. MXP. maxilliped, B. arch-shaped bandage × 75.
Fig. 25. Gland at both side of stmach. × 140.
Fig. 26. Mandible. × 350.
Fig. 27. Second antenna. × 250.
Fig. 28. First swimming leg. × 300.
Fig. 29. Third swimming leg × 200.
Fig. 30. Muscles in swimming leg. × 200.
Fig. 31. Cross section of gland on both sides of stomach. H. horn, G. gland, S stmach, A. symbiotic alga. × 60.
Fig. 32. Cross section of posterior part of fifth thoracic segment. I. intestin, R. rectum, CG. cement gland, PP. pregenital prominence. × 50.
Fig. 33. Longitudinal section of cephalothorax. C. cephalon, G. gland, MXP. maxilliped, 1L. first swimming leg. × 100.
Fig. 34. Cross section of middle part of fifth thoracic segment. OV. ovary, OD. oviduct, CG. cement gland. × 50.
Fig. 35. Inner layer of skin. N. nucleus. × 75.
Fig. 36. Stomach wall. A. symbiotic alga, N. nucleus. × 675.
Fig. 37. Cement gland. × 675.

Fig. 38. Longitudinal section of anterior part of body. S. stomach, I. intestin, M. muscle. × 40.

Fig. 39. Cross section of fouth thoracic segment. I. intestin, OD. oviduct. × 50.

Fig. 40. Cross section at posterior part of fouth thoracic segment. CG. cement gland, OD. oviduct, IL. inner layer, ML. middle layer, OL. outer layer, PP pergenital prominence. × 35.

Fig. 41. vid Pl. I.

ON THE NATURE OF WATER AND BOTTOM OF FISH REARING PONDS.

I. On a case of Damage done to the Cultivated Fish by Acid Soil.

(Contributions from the Toyohashi Piscicultural Experiment Station No. 2.)

By

Yoshiichi Matsui and Tokujiro Yamada.

We often hear that in the ponds in coastal districts a good many of cultivated fish die after rainfalls.

The present report is an instance of the same event that occurred in the Muro Fish Rearing Pond belonging to our Station in June 1922, and in the neighboring pond in July 1922 where the water in those ponds showed decidedly an acid reacrion.

The dead fish looked as if they were coated by a membrane due to the coagulation of viscous fluid, excepting their cornea. The gills and livers were conspicuously congested.

The analyses of the neighboring soils plainly showed the presence of acid one. We noticed a gray substance on the surface of the soil. This substance is composed of insoluble silicate and soluble salts and the later is proved to contain a large quantity of aluminium sulphate, and from the solution of the soluble salts just mentiond we obtained a beautiful hexagonal crystals. And when water contains more than 0.02% of this substance it kills eels and its reaction upon fish is the same as that of

alum; in its higher density it is slower than that of alum and vice versa. This may probably be due to the antagonism of many other salts contained in the solution than alum.

Although the damage due to the acid soil decreases year by year, yet the anhibation of the danger can be attainned in preventing rain drains from running down the banking into the pond, and also in neutralizing the soil by milk of lime on the banking.

In the case when the water of ponds turns acid, we may neutralize it by means of milk of lime also; the contents of lime should not be over 2 grs. in 100,000 c.c. of water. The toxic reaction of lime upon fishes decreases rapidly in the case wher a large quantity of organic matter is present in the fish rearing ponds.

(Abstracted from the text written in Japanese.)

November 1924.

ON THE NATURE OF WATER AND BOTTOM OF FISH REARING PONDS.

II. Analytical Table compiled up to the fiscal year 1926.

(Contributions from the Toyohashi Piscicultural Experiment Station. No. 3.)

By

Tokujiro Yamada.

The tables are the results of analysis of many samples of water and soil that were brought to our Experiment Station to ascertain their fitness for fish rearing for the construction of new ponds, and also contain the analysis made when unusual phenomena happened in the ponds. Therein also contained those tables jointly done with Mr. Y. Matsui for the Fundamental studies of water and bottomsoils of fish ponds.

The tables are put in print, though fragmentary, for the referrence to our future study. (Unit for waterquality is milligram per 1000 c.c. and for bottom-soil is gram per 100 gr.)

December 1926.

大正十五年度迄ニ蒐集セル水質及底質分析表

I. 平常池水 NORMAL POND WATER

ANALYTICAL TABLES COMPILED UP TO THE FISCAL YEAR 1926.

番號 No.	年月日 Date	反應 Reaction	蒸發殘渣 Total Solid Residue	熾灼殘渣 Mineral Matter	熾灼減量 Loss in Ignition	浮遊性物 Suspended Dry Matter	硫酸 SO_3	燐酸 P_2O_5	炭酸 CO_2	硝酸 N_2O_5	亞硝酸 N_2O_3	クロール Cl	硫化水素 H_2S	アンモニア NH_3	石灰 Ca	マクネシウム Mg	鐵 Fe	アルミニウム Al	カリ K	ナトリウム Na	有機質 Organic Matter
72	7月 日 July, 22nd. 1922	中性 Neutral	1635.00	1256.00	379.00	64.60	49.00	8.44	0	0	0	744.45	0	5.00	79.29	27.24	34.65	53.30	12.16	294.21	—
73 (I)	〃	微弱アルカリ性 Slight Weak Alkali	2825.00	2115.00	710.00	66.00	93.00	25.96	6.00	0	0	1276.20	0	痕跡 Trace	67.86	40.96	144.20	57.56	19.20	771.47	—
73 (II)	〃		244.00	157.00	87.00	80.00	74.58	—	—	0	痕跡 Trace	134.00	0	痕跡 Trace	—	12.68	—	—	—	6.00	123.24
8	12月 日 Dec., 1st. 1921	中性 Neutral	630.00	457.00	173.00	53.00	8.74	—	—	痕跡 Trace	0	212.70	0	0.25	555.00	26.65	—	—	—	138.30	31.60
1	7月 日 July, 10th. 1921	中性 〃	850.00	599.00	256.00	20.00	0.01	—	—	0	0	355.00	0	痕跡 Trace	—	—	—	—	—	230.00	18.96
102	7月 日 July, 22nd. 1926	中性 〃	243.40	122.00	121.40	127.00	9.00	46.38	76.50	0	0	17.73	0	1.50	22.20	11.30	8.40	痕跡 Trace	5.00	13.00	86.90
48	8月 日 Aug., 16th. 1924	中性 〃	2767.00	2189.00	578.00	18.10	144.20	20.80	—	0	0	1240.75	0	0	—	65.57	47.50	39.44	28.93	899.55	—
26	8月 日 Aug., 1st. 1923	中性 〃	1008.00	671.00	—	—	46.00	痕跡 Trace	—	0	0	411.00	0.85	0.10	50.00	16.00	33.00	45.00	18.00	29.00	337.00
27	〃 6月 日	中性 〃	1251.00	830.00	—	—	54.00	痕跡 Trace	—	0	0	532.00	7.00	0.50	56.00	69.00	9.00	48.00	18.00	29.00	42.00
25	June, 〃 1923	中性 〃	460.00	335.00	—	—	25.00	—	—	—	—	22.00	—	1.00	89.00	11.00	6.00	2.00	—	—	125.00
50	9月 日 Sept., 13th. 1924	中性 〃	357.00	—	—	212.00	26.30	—	—	—	—	14.18	—	僅微 Slight	25.00	4.50	17.50	—	—	—	50.00
51	〃 11月 日	中性 〃	310.00	—	—	180.00	35.70	—	—	—	—	21.27	—	僅微 Slight	105.00	3.98	18.90	—	—	—	10.00
54	Nov., 30th. 1924	微弱アルカリ性 Slight Weak Alkali	1191.00	867.00	—	12.00	37.70	22.40	39.00	0	0	53.18	0.68	0	372.00	52.00	19.25	48.00	9.70	254.00	324.00
55	〃 1月 日	微弱アルカリ性 〃	1205.00	918.00	—	32.00	89.60	4.47	51.00	0	多量 Abundant	53.18	0.68	14.00	—	6.00	62.00	22.00	4.54	35.00	287.00
61	Jan., 16th. 1925	中性 Neutral	2599.00	1903.00	—	99.00	57.00	70.00	75.00	痕跡 Trace	痕跡 Trace	1134.00	0	15.00	286.00	65.00	36.00	100.00	15.40	540.00	686.00
28	8月 日 Aug., 24th. 1923	中性 〃	1500.00	1035.00	—	48.00	57.00	痕跡 Trace	—	0	著明 Remarkable	628.00	0	0	221.00	11.00	48.00	21.00	55.00	140.00	417.00
64	2月 日 Feb., 1925	中性 〃	1511.00	109.00	—	75.00	56.00	8.57	90.00	0	0	609.70	—	15.00	60.70	5.20	6.30	64.00	13.40	446.00	421.00
32	8月 日 Aug., 25th. 1923	中性 〃	225.00	168.00	—	60.00	11.00	0	—	痕跡 Trace	痕跡 Trace	121.00	0	痕跡 Trace	45.00	4.00	0	2.00	87.00	26.00	97.00
31	8月 日 Aug., 24th. 1923	中性 〃	955.00	280.00	—	51.00	38.00	痕跡 Trace	—	痕跡 Trace	著明 Remarkable	177.00	0	0	31.00	5.00	10.00	61.00	25.00	81.00	624.00
29	8月 日 Aug., 24th. 1923	中性 〃	1215.00	675.00	—	35.00	56.00	痕跡 Trace	—	痕跡 Trace	痕跡 Trace	377.00	0	0	81.00	7.00	43.00	44.00	19.00	88.00	505.00
30	〃 8月 日	中性 〃	955.00	700.00	—	90.00	52.00	0	—	0	0	301.00	0	0	401.00	9.00	20.00	63.00	126.00	24.00	255.00
33	Aug., 25th. 1923	中性 〃	4905.00	3305.00	—	20.00	221.00	0	—	0	0	3846.00	0	0	261.00	22.00	76.00	153.00	372.00	1110.00	1580.00
82	8月 日 Aug., 8th. 1925	中性 〃	251.00	193.00	58.00	82.00	31.93	9.70	—	0	0	212.70	0	5.00	48.57	15.35	44.00	30.00	0.04	58.00	—
83	8月 日 Aug., 10th 1925	中性 〃	2833.00	2641.00	192.00	18.00	181.28	10.49	—	0	0	1595.00	0	4.00	82.85	44.54	146.30	13.25	5.28	836.00	—
81	8月 日 Aug., 8th. 1925	中性 〃	149.00	96.40	52.60	84.00	1.34	7.16	—	0	0	8.86	0	7.00	40.00	7.35	15.40	0	痕跡 Trace	37.00	—
80	8月 日 Aug., 7th. 1925	微弱アルカリ性 Slight Weak Alkali	8901.00	5765.00	3136.00	61.60	406.00	4.86	—	0	痕跡 Trace	3261.40	0	0	157.86	90.59	137.20	182.82	22.00	1918.00	—
79	8月 日 Aug., 6th 1925	中性 Neutral	3171.00	2651.00	520.00	100.00	199.48	9.59	—	0	0	1595.25	0	0	45.72	43.24	55.30	109.27	17.28	1257.00	—
77	8月 日 Aug., 5th. 1925	微弱アルカリ性 Slight Weak Alkali	1122.00	927.00	195.00	145.00	16.00	11.63	—	0	痕跡 Trace	319.00	0	27.00	72.14	14.70	84.70	4.42	6.40	403.00	—
78	1月 日 Jan., 12th. 1925	中性 Nentral	529.00	341.00	188.00	7.00	13.00	4.55	—	0	痕跡 Trace	169.16	0	0.50	45.72	11.76	5.70	2.67	8.00	123.00	—
93	8月 日 Aug., 4th. 1926	中性 Neutral	126.40	81.00	45.40	4.50	1.40	1.63	—	0	0	10.64	0	0	63.97	11.47	24.39	23.45	0.25	14.52	17.38
76	1月 日	中性 〃	242.90	195.00	479.00	99.00	1157.00	7.00	—	0	痕跡 Trace	1063.50	0	27.00	97.14	31.13	147.70	64.65	12.80	575.00	—
94	Jan., 12th. 〃	微弱アルカリ性 Slight Weak Alkali	155.00	113.40	41.60	10.30	10.84	6.37	—	0	0	10.64	0	0	57.14	31.29	29.00	23.45	痕跡 Trace	9.38	6.32
95	〃	微弱アルカリ性 〃	122.00	77.40	44.60	9.20	16.00	15.91	—	0	0	7.09	0	0	62.18	20.44	11.94	32.51	2.00	12.77	18.91
96	〃 9月 日	中性 Neutral	167.40	106.80	60.60	22.00	7.90	0	—	0	0	17.73	0	9.50	49.64	1.95	18.06	1.71	0.85	29.68	39.50
87	Sept., 5th. 1925	中性 〃	121.00	78.00	43.00	9.80	105.00	0	—	0	0	14.18	0	0	48.58	痕跡 Trace	51.80	0	9.00	45.00	18.96
104	9月 日 Sept., 7th. 1926	中性 〃	300.40	111.40	189.00	141.00	12.90	4.26	—	0	痕跡 Trace	14.18	0	2.50	30.21	12.17	14.11	4.26	0	15.70	186.60

II. 異常池水 ABNORMAL POND WATER

番號 No.	年月日 Date	反應 Reaction	蒸發殘渣 Total Solid Residue	熾灼殘渣 Mineral Matter	熾灼減量 Loss in Ignition	浮遊性物 Suspended Dry Matter	硫酸 SO_3	燐酸 P_2O_5	炭酸 CO_2	硝酸 N_2O_5	亞硝酸 N_2O_3	クロール Cl	硫化水素 H_2S	アンモニア NH_3	石灰 Ca	マグネシウム Mg	鐵 Fe	アルミニウム Al	カリ K	ナトリウム Na	有機質 Organic Matter
53	11月 日 Nov., 3rd. 1924	中性 Neutral	277.00	138.60	—	92.50	24.37	14.60	145.20	0	0	49.63	—	1.25	238.58	21.62	24.50	34.65	36.80	52.25	138.40
35	5月 日 May., 2nd. 1924	微アルカリ性 Slight Alkali	207.50	—	—	44.00	64.50	28.14	—	0	0	28.36	—	250.00	—	—	0	26.11	—	—	52.14
14	10月 日 Oct., 15th. 1922	中性 Neutral	1705.00	475.00	—	—	29.00	—	—	0	0	36.00	—	著明 Remarkable	—	—	30.00	7.00	—	23.00	123.00
6	8月 日 Aug., 13th. 1921	中性 〃	454.00	134.00	320.00	170.00	0.01	—	—	0	0	27.00	0	僅微 Slight	—	—	—	—	—	19.00	88.48
2	7月 日 July., 25th. 1925	中性 〃	323.00	207.00	116.00	30.00	67.00	—	—	0	痕跡 Trace	29.00	0	0	—	—	—	—	—	19.00	134.00
58	12月 日 Dec., 9th. 1924	微アルカリ性 Slight Alkali	400.00	205.00	—	—	22.30	—	329.00	痕跡 Trace	痕跡 Trace	60.27	—	0	170.00	8.86	35.00	32.51	10.08	24.60	195.00
74	7月 日 July, 22nd. 1925	中性 Neutral	1693.00	1248.00	445.00	38.80	76.50	4.47	—	0	11.75	709.00	0	痕跡 Trace	49.29	11.67	34.90	46.12	12.25	293.00	—
75	7月 日 July, 30th. 1925	微弱アルカリ性 Slight Weak Alkali	1862.00	1384.00	478.00	57.40	71.00	26.00	—	0	11.75	797.63	0	痕跡 Trace	52.86	41.94	9.80	71.42	21.76	424.51	—
7	12月 日 Dec., 1st. 1921	中性 Neutral	5599.00	4502.00	1097.00	150.00	455.90	—	—	痕跡 Trace	0	2587.85	0	0.75	480.37	55.29	—	—	—	1682.65	6.32
7 II	〃	中性	2572.00	1810.00	767.00	27.00	134.05	—	—	0	痕跡 Trace	887.00	0	僅微 Slight	—	84.31	—	—	—	576.00	3.16
17	1922	Neutral	9095.00	7375.00	—	230.00	789.00	—	—	—	—	3732.00	850.00	150.00	149.00	108.00	—	261.00	—	2732.00	—
11	7月 日 July., 23rd. 1922	微弱アルカリ性 Slight Weak Alkali	748.00	400.00	—	175.00	68.50	—	25.00	0	—	241.00	—	0	51.00	43.00	—	37.00	16.00	33.00	175.00
15	10月 日 Oct., 21st. 1922		8885.00	6880.00	—	—	496.00	—	—	—	—	2945.00	—	痕跡 Trace	23.00	21.00	—	16.00	—	—	2005.00
16	〃		7215.00	5625.00	—	—	413.00	—	—	0	0	2910.00	—	0	17.00	21.00	—	11.00	—	—	1590.00
34	2月 日 Feb., 24th. 1924	中性 Neutral	3359.00	2527.00	—	16.00	165.00	620.00	—	—	僅微 Slight	749.00	—	26.00	—	73.00	184.00	14.00	69.00	676.00	832.00
49	8月 日 Aug., 16th. 1924	〃	5187.00	3338.00	1849.00	25.50	226.30	11.07	—	0	0	1949.75	0	19.00	—	174.80	151.80	61.19	37.12	1069.51	—
52	9月 日 Sept., 14th. 1924	微弱アルカリ性 Slight Weak Alkali	10177.00	5107.00	5070.00	—	315.90	6.95	323.80	—	—	3190.00	—	1.50	228.07	167.99	36.40	319.43	632.00	1136.60	474.00
12	10月 日 Oct., 10th. 1922	微アルカリ性 Slight Alkali	1285.50	1044.50	—	10.25	74.50	—	—	0	0	631.00	0	僅微 Slight	5.01	3.64	—	1.78	—	410.00	241.00
13	〃	微アルカリ性 〃	763.50	625.50	—	2.75	44.60	—	—	0	0	373.00	0	著明 Remarkable	3.76	2.84	—	7.96	—	241.00	138.00
108		中性 Neutral	26790.00	20670.00	—	—	1393.00	痕跡 Trace	—	0	0	8863.00	21.00	0	521.00	99.00	154.00	829.00	—	5762.00	3060.00
36	5月 日 May, 17th. 1924	微アルカリ性 Slight Alkali	3730.00	2880.00	—	—	190.00	—	—	痕跡 Trace	少量 Little	1684.00	—	0	—	7.00	9.00	10.00	99.50	16.00	850.00
37	5月 日 May, 18th. 1924	微弱アルカリ性 Slight Weak Alkali	1925.00	1480.00	—	42.50	223.00	18.60	—	0	0	1758.00	23.00	17.00	—	60.80	108.00	42.00	49.20	323.40	445.00
65	2月 日 Feb., 1925	微アルカリ性 Slight Alkali	1538.00	1157.00	371.00	188.00	21.00	55.00	—	0	0	992.60	7.31	27.00	58.57	33.73	28.70	37.84	15.20	576.00	—
66	〃	微アルカリ性 〃	2510.00	2015.00	495.00	90.00	65.00	91.30	—	0	著明 Remarkable	1170.00	12.75	27.00	83.00	40.00	9.70	129.52	12.00	—	—
62	1月 日 Jan., 16th. 1925	中性 Neutral	1260.00	979.00	—	82.40	43.00	43.80	420.00	—	—	567.00	—	痕跡 Trace	136.00	44.00	103.00	80.00	10.36	346.00	281.00
56	11月 日 Nov., 30th. 1924	微弱アルカリ性 Slight Weak Alkali	2212.00	1851.00	—	48.00	122.90	11.50	51.00	少量 Little	痕跡 Trace	109.90	0.34	5.50	118.57	103.78	259.70	21.32	19.52	567.60	361.00
57	〃	アルカリ性 Alkali	6659.00	5885.00	—	80.00	427.40	159.38	24.00	0	0	335.00	0.51	0	112.15	223.98	43.75	276.32	18.24	817.20	2854.00
100	5月 日 May, 23rd. 1926	弱アルカリ性 Weak Alkali	1022.40	844.40	178.00	67.40	14.62	64.15	3.00	0	僅微 Slight	460.85	0	0.14	68.00	10.44	39.41	1.22	18.65	563.00	99.54
101	〃	〃	967.40	614.40	353.00	132.40	33.16	51.26	3.60	0	痕跡 Trace	389.95	0	0.18	44.00	39.8	30.90	14.65	6.72	158.00	90.60
42	7月 日 July, 12th. 1924	微アルカリ性 Slight Alkali	—	—	—	164.00	809.80	0	—	痕跡 Trace	0	—	14.20	痕跡 Trace	—	1737.50	13.30	痕跡 Trace	—	6666.70	230.70
9	6月 日 June., 11th. 1922	微弱酸性 Slight Weak Acid	1350.00	—	—	250.00	72.96	—	—	0	0	42.85	—	0.06	81.11	96.38	193.45	—	—	—	0.95
10	7月 日 July, 5th. 1922	微弱酸性 〃	1200.00	775.00	427.00	—	268.00	—	65.00	—	—	241.00	—	50.00	254.00	35.00	—	—	—	—	1058.60
103	8月 日 Aug., 4th. 1926	アルカリ性 Alkali	10880.00	8788.00	2092.00	280.50	620.53	38.67	45.00	0	0	5246.60	0	0	292.00	94.38	88.30	215.32	20.00	2742.30	210.14

III. 川　　水 RIVER WATER

番號 No.	年月日 Date	反應 Reaction	蒸發殘渣 Total Solid Residue	熾灼殘渣 Mineral Matter	熾灼減量 Loss In Ignition	浮遊性物 Suspended Dry Matter	硫酸 SO_3	燐酸 P_2O_5	炭酸 CO_2	硝酸 N_2O_5	亞硝酸 N_2O_3	クロール Cl	硫化水素 H_2S	アンモニア NH_3	石灰 Ca	マグネシウム Mg	鐵 Fe	アルミニウム Al	カリ K	ナトリウム Na	有機質 Organic Matter
23	5月 日 May, 4th. 1923	中性 Neutral	—	260.00	—	10.00	21.00	0	—	0	0	92.00	—	0	100.00	0	痕跡 Trace	13.00	27.00	89.00	0
24	5月 日 May, 4th. 1922	中性 〃	—	315.00	—	—	89.00	痕跡 Trace	—	0	0	106.00	—	0	48.00	0	痕跡 Trace	25.00	0	70.00	95.00
69	6月 日 June, 9th. 1925	中性 〃	89.00	85.00	—	—	32.00	—	—	0	0	8.86	—	0	30.00	—	2.60	9.60	2.50	5.76	5.00
45	7月 日 July, 28th. 1924	中性 〃	44.00	31.40	12.60	3.00	6.22	3.92	—	0	0	6.13	—	0	—	1.00	2.50	1.17	1.18	3.00	0.79
41	6月 日 June, 27th. 1924	中性 〃	46.60	32.40	14.20	0.50	6.30	—	—	0	0	5.30	—	0	9.30	1.60	1.00	2.40	—	—	79.00
38	6月 日 June, 26th. 1924	中性 〃	57.60	42.00	15.60	2.00	7.50	—	—	0	0	6.00	—	0	20.00	1.30	1.00	3.50	—	—	79.00
39	〃	中性 〃	70.60	55.00	15.00	10.00	3.40	—	—	0	0	7.10	—	7.00	11.00	0.90	1.50	1.70	—	—	174.00
40	6月 日 June, 26th. 1924	中性 〃	86.00	59.00	21.00	14.00	4.80	—	—	0	痕跡 Trace	7.10	—	9.00	4.20	0.90	1.70	0.80	—	—	237.00
19	1924	中性 〃	130.00	70.00	—	—	22.00	—	—	0	0	27.00	—	0	—	8.00	—	—	—	—	60.00

IV. 湖　　水 LAKE WATER

番號 No.	年月日 Date	反應 Reaction	蒸發殘渣 Total Solid Residue	熾灼殘渣 Mineral Matter	熾灼減量 Loss, in Ignition	浮遊性物 Suspended Dry Matter	硫酸 SO_3	燐酸 P_2O_5	炭酸 CO_2	硝酸 N_2O_5	亞硝酸 N_2O_3	クロール Cl	硫化水素 H_2S	アンモニア NH_3	石灰 Ca	マグネシウム Mg	鐵 Fe	アルミニウム Al	カリ K	ナトリウム Na	有機質 Organic Matter
63	1月 日 Jan., 16th. 1625	中性 Neutral	25288.00	25195.00	—	—	1703.00	64.00	—	—	—	6180.00	—	—	—	935.00	124.00	—	146.00	3236.00	93.00
84	9月 日 Sept., 4th. 1925	微弱アルカリ性 Slight Weak Alkali	35515.00	20655.00	18865.00	0	1455.70	—	30.00	0	0	12407.50	—	0	495.72	589.36	907.20	419.47	80.00	14653.00	711.00
85	〃	微弱アルカリ性 〃	36280.00	20135.00	16145.00	0	1346.95	—	27.00	0	0	12407.50	—	0	263.58	93.85	96.88	92.74	84.80	6166.36	869.00
86	〃	中性 Neutral	30540.00	23915.00	6625.00	18.00	1607.90	—	27.00	0	0	14180.00	—	0	252.86	103.78	952.70	231.86	76.00	1526.34	1346.00
89	12月 日 Dec., 11st. 1925	微弱アルカリ性 Slight Weak Alkali	70.00	48.40	—	5.00	26.00	2.05	—	0	0	7.10	0	2.00	6.43	5.92	2.06	1.28	022	27.17	11.60
92	1月 日 Jan., 12th. 1926	微弱アルカリ性 〃	94.40	62.80	31.63	11.00	22.48	3.07	—	0	0	14.18	0	0	31.43	13.40	3.95	19.19	痕跡 Trace	16.85	36.34
43	7月 日 July, 28th. 1924	微アルカリ性 Slight Alkali	40.60	29.70	10.90	0.50	4.06	3.75	—	0	0	6.18	—	0	—	1.73	3.00	0.76	1.06	2.80	1.26
44	7月 日 July, 28th. 1924	微 アルカリ性 〃	31.40	30.40	1.00	0	5.20	3.66	—	0	0	2.09	—	0	—	0.92	2.04	0.78	0.60	2.03	0.63

V. 湧　　水 SPRING WATER

番號 No.	年月日 Date	反應 Reaction	蒸發殘渣 Total Solid Residue	熾灼殘渣 Mineral Matter	熾灼減量 Loss, in Ignition	浮遊性物 Suspended Dry Matter	硫酸 SO_3	燐酸 P_2O_5	炭酸 CO_2	硝酸 N_2O_5	亞硝酸 N_2O_3	クロール Cl	硫化水素 H_2S	アンモニア NH_3	石灰 Ca	マグネシウム Mg	鐵 Fe	アルミニウム Al	カリ K	ナトリウム Na	有機質 Organic Matter
20	5月 日 May, 1st. 1923	微アルカリ性 Slight Alkali	—	180.00	—	—	15.00	0	—	0	0	56.00	—	0	75.00	6.00	—	7.00	8.00	37.00	40.00
21	5月 日 May, 1st. 1923	微弱アルカリ性 Slight Weak Alkali	—	120.00	—	—	2.00	痕跡 Trace	—	0	0	35.00	—	0	31.00	0	—	16.00	7.00	24.00	0
22	5月 日 May, 3rd. 1923	中性 Neutral	—	250.00	—	—	23.00	痕跡 Trace	—	0	0	21.00	—	0	157.00	0	—	6.00	5.00	19.00	35.00
46	7月 日 July, 28th. 1924	微アルカリ性 Slight Alkali	50.00	36.00	14.00	10.00	3.66	3.32	—	0	0	4.09	—	0	—	1.00	0.23	1.71	0.72	1.78	0

VI. 井　　水　WELL WATER

番號 No.	年　月　日 Date	反　應 Reaction	蒸發殘渣 Total Solid Residue	熾灼殘渣 Mineral Matter	熾灼減量 Loss, in Ignition	浮遊性物 Suspended Dry Matter	硫　酸 SO_3	燐　酸 P_2O_5	炭　酸 CO_2	硝　酸 N_2O_5	亞硝酸 N_2O_3	クロール Cl	硫化水素 H_2S	アンモニア NH_3	石　灰 Ca	マグネシウム Mg	鐵 Fe	アルミニウム Al	カ　リ K	ナトリウム Na	有機質 Organic Matter
4	7月　日 July, 27th. 1921	—	89.70	63.35	26.35	—	0.01	—	—	0	0	7.14	—	0	—	—	—	痕　跡 Trace	—	—	0
5	〃	—	89.20	61.60	27.60	—	0.02	—	—	0	0	14.28	—	0	—	—	—	痕　跡 Trace	—	—	0
105	12月　日 Dec., 7th. 1926	微弱アルカリ性 Slight Weak Alkali	137.40	110.20	27.20	—	4.00	—	—	0	0	10.64	0	0	14.04	2.19	13.06	7.20	0	8.26	230.00
106	〃	微弱アルカリ性 〃	329.60	243.60	86.00	—	10.00	—	—	痕　跡 Trace	0	42.54	0	0	45.11	9.33	28.81	27.45	0	18.49	316.00
107	〃	微弱アルカリ性 〃	126.60	96.60	30.00	—	9.15	—	—	0	0	10.64	0	0	11.18	3.82	10.61	0.53	0	7.47	37.92
91	1月　日 Jan., 12nd. 1926	中　性 Neutral	180.20	138.20	42.00	—	—	—	—	0	0	10.63	0	0	43.20	0.65	28.65	13.00	—	—	79.25
98	3月　日 March, 31st. 1926	微弱アルカリ性 Slight Weak Alkali	127.40	96.40	31.00	—	21.45	—	—	0	痕　跡 Trace	7.09	—	痕　跡 Trace	18.57	1.19	12.71	4.18	—	—	31.60
99	〃	微弱アルカリ性 〃	120.40	93.00	27.40	—	21.29	—	—	0	0	7.09	—	0	21.18	1.43	11.65	5.33	—	—	17.38
71	7月　日 July, 8th. 1925	中　性 Neutral	156.40	102.40	54.00	—	19.00	—	30.00	0	0	10.64	—	0	27.86	—	32.20	—	—	—	23.70
90	12月　日 Dec., 28th. 1925	中　性 〃	201.00	156.40	44.60	—	20.00	—	—	0	0	28.00	—	0	67.14	19.67	35.00	27.30	—	—	9.48
68	6月　日 June, 5th. 1925	中　性 〃	456.00	317.00	—	—	4.00	—	—	0	0	88.63	—	少　量 Little	140.00	—	3.00	77.00	—	—	584.00
59	1月　日 Jan., 8th. 1925	中　性 〃	269.00	212.40	—	14.00	47.00	—	—	0	0	43.00	—	0	—	36.00	50 25	37.30	6.00	34.00	6.00
60	〃	中　性 〃	282.00	204.00	—	17.00	30.00	—	—	0	0	40.00	—	0	—	31.00	25.00	31.00	6.00	28.00	8.00
47	8月　日 Aug., 14th. 1924	中　性 〃	212.60	162.00	50.60	—	0.31	—	—	0	0	31.91	痕　跡 Trace	著明 Remarkable	8.48	4.53	24.62	7.07	—	—	40.15
3	7月　日 July, 26th. 1921	中　性 〃	98.00	72.00	26.00	—	0.62	—	—	痕　跡 Trace	痕　跡 Trace	7.00	0	0	—	—	—	0	—	5.00	0
67	4月　日 April, 24th. 1925	微弱アルカリ性 Slight Weak Alkali	1884.00	—	—	3.60	14.00	—	7.50	痕　跡 Trace	0	39.00	—	24.00	264.00	痕　跡 Trace	42.00	69.00	—	—	25.02
70	7月　日 July, 5 h. 1925	中　性 Neutral	136.40	127.40	9.00	—	2.50	—	15.00	0	0	8.86	—	0	80.00	—	3.00	—	—	—	0
88	11月　日 Nov., 8th. 1925	中　性 〃	2963.20	2017.20	896.00	—	80.00	—	—	0	0	1205.30	—	0	290.00	125.00	151.00	142.00	3.10	502.00	0
97	2月　日 Feb., 12th. 1926	微弱アルカリ性 Slight Weak Alkali	165.40	119.40	46.00	12.50	18.76	15.25	—	0	0	7.09	0	8.50	24.68	1.52	20.85	4.06	3.50	15.30	37.92
18	4月　日 April, 24th. 1923	中　性 Neutral	157.00	—	—	—	—	0	—	0	0	7.00	—	0	42.00	—	—	痕　跡 Trace	10.00	37.00	0

番號 No.	年 月 日 Date	反應 Reaction	受水量 Absorptive Power	乾燥殘渣 Dry Residue	水分 Moisture	熾灼減量 Loss in Ignition	熾灼殘渣 Mineral Matter	酸ニ可溶性成分 soluble matter in HCl	酸ニ不溶性成分 non-soluble matter in hcl	水ニ可溶性成分 soluble matter in wate	水ニ不溶性成分 nol-soluble matter in water	可溶性有 soluble rogan matter wate
3	8月 日 Aug., 2nd. 1922	中性 Neutral	4.1375	97.500	2.500	—	89.150	11.353	80.292	3.000	97.000	8.
4	〃	中性 〃	—	97.575	2.425	—	87.075	20.140	79.860	6.390	93.610	10.
5	4月 日 April, 22nd. 1923	微弱酸性 Slight Weak Acid	—	96.950	3.050	5.420	91.530	12.734	84.216	3.050	96.950	
6	〃	微弱酸性 〃	—	95.400	4.600	8.650	86.750	20.530	79.470	10.150	89.850	
1	12月 日 Dec., 1st. 1921	——	—	98.850	1.150	5.730	94.270	—	—	0.685	—	0.
2	〃		—	97.150	2.850	10.620	89.380	—	—	0.135	—	0.
17	7月 日 July, 5th. 1924	中性 Neutral	60.000	96.450	3.550	10.560	89.440	18.140	81.860	3.000	97.000	
18	〃	中性 〃	48.000	99.270	0.730	3.880	96.120	6.860	93.140	0.962	99.038	
13	3月 日 March, 24th. 1924	微弱アルカリ性 Slight Weak Alkali	35.000	99.250	0.750	3.750	95 500	9.700	90.300	1.394	98.606	
19	9月 日 Sept., 4th. 1924	中性 Neutral	58.000	95.650	4.350	15.530	80.120	17.210	78.440	3.554	92.096	
20	〃	中性 〃	62.000	96.500	3.500	11.500	85.000	12.932	83.568	0.690	95.810	
21	9月 日 Sept., 14th. 1924	中性 〃	—	97.500	2.500	7.250	90.250	9.780	90.220	3.970	96.630	
26	7月 日 July, 18th. 1925	微弱酸性 Slight Weak Acid	44.000	99.200	0.800	3.750	96.250	8.990	91.010	1.110	98.890	0.
45	7月 日 July, 22nd. 1926	微弱酸性 〃	46.000	99.330	0.680	3.580	96.420	7.668	92 332	0.780	99.220	0.
7	8月 日 Aug., 1st. 1923	中性 Neutral	—	97.890	2.110	11.430	88.570	17.150	82.850	3.150	96.850	
8	8月 日 Aug., 1st. 1923	中性 〃	—	97.000	3.000	13.470	86.530	20.550	79.450	3.998	96.002	
11	12月 日 Dec., 25th. 1923	中性 〃	—	98.000	2.000	2.100	97.900	11.113	88.887	0.480	99.520	
14	5月 日 May, 17th. 1924	微弱アルカリ性 Slight Weak Alkali	56.000	95.610	4.390	10.350	85.260	15.780	84.220	6.950	93.050	
15	5月 日 May, 18th 1924	微弱アルカリ性 〃	57.000	96.950	3.050	11.200	85.750	14.846	85.154	5.200	34.800	
16	〃	〃	45.000	98.560	1.440	5.750	92.810	8.390	91.610	2.980	97.020	
28	8月 日 Aug., 6th. 1925	中性 Neutral	45.000	96.370	3.250	7.410	92.590	8.660	91.400	3.916	96.084	
27	8月 日 Aug., 5th. 1925	中性 〃	59.000	97.820	2.180	7.720	90.100	6.020	93.980	2.600	98.400	
33	8月 日 Aug., 20th. 1925	微弱酸性 Slight Weak Acid	55.000	97.720	2.280	12.050	87.950	14.110	85.890	3.324	96.676	
29	8月 日 Aug., 1925	微弱酸性 〃	44.000	99.280	0.720	4.120	95.880	7.546	92.454	1.136	98.864	0.
30	〃	微弱酸性 〃	60.000	96.760	3.240	24.500	78.500	28.750	71.250	10.030	89.970	1.
31	〃	中性 Neutral	53.000	98.850	1.150	7.400	92.600	14.230	85.770	2.094	97.906	0.
32	〃	微弱酸性 Slight Weak Acid	45.000	98.750	1.250	7.550	92.450	11 004	88.996	0.790	99.210	0.
9	8月 日 Aug., 24th. 1923	微弱酸性 〃	—	96.950	3.050	17.100	82.900	28.420	71.580	4.670	25.330	
10	〃	中性 Neutral	—	98.950	1.050	3.440	95.510	4.620	95.380	3.750	96.250	
23	11月 日 Nov., 30th. 1924	微弱アルカリ性 Slight Weak Alkali	—	98 000	2.000	7.700	90 300	11.720	4.670	4.670	95.330	
24	〃	中性 Neutral	—	98.380	1.620	7.000	91.380	10.600	89.400	2.200	97.800	
22	9月 日 Sept., 13rd. 1924	微弱酸性 Slight Weak Acid	45.000	97.790	2.210	8.750	89.040	16.066	83.934	1.950	98.050	
43	5月 日 May, 23rd. 1926	微弱酸性 〃	52.000	98 590	1.410	8.010	91.990	10.020	89.980	2.284	97.716	0.
44	〃	微弱酸性 〃	59.000	94.900	5.100	15.150	84.850	17.690	82.310	2.490	97.510	1.
46	9月 日 Sept., 7th. 1926	微弱酸性 〃	59.000	98.850	1.150	8.800	91.200	6.470	93.530	1.880	98.120	0.
34	12月 日 Dec., 25th. 1925	微弱酸性 〃	56.000	99.450	0.550	13.530	86.470	10.190	89.810	3.240	96.760	
35	〃	微弱酸性 〃	55.000	97.040	2.960	12.660	87.340	11.610	88.390	3.038	96.962	
36	12月 日 Dec., 25th. 1925	微弱酸性 〃	65.000	93.820	6.180	52.480	47.520	41.046	59.954	5.910	94.090	
37	1月 日 Jan., 12th. 1926	微弱酸性 Slight Weak Acid	58.000	97.030	2.970	14.100	85.900	18.970	81.030	3.780	96.220	
38	〃	微弱酸性 〃	63.000	93.750	6.250	37.850	62.150	26.578	73.422	3.740	96.260	
39	1月 日 Jan., 12th.	微弱アルカリ性 Slight Weak Alkali	62.000	95.110	4.890	27.630	72.370	35.930	64.070	4.600	95.400	
40	〃	微弱酸性 Slight Weak Acid	52.000	98.200	1.800	8.950	91.050	11.080	88.920	2.510	97.490	0.
41	〃	微弱アルカリ性 Slight Weak Alkali	42.000	99.220	0.780	4.530	95.470	8.070	91.930	1.068	98.932	0.
42	〃	微弱アルカリ性 〃	58.000	96.620	3.380	15.480	84.520	24.520	75.480	3.200	96.800	0.
12	2月 日 Feb., 10th. 1924	中性 Neutral	38.000	98.980	1.020	4.700	94.280	13.284	86.716	2.570	97.430	
25	4月 日 April, 12th. 1925	中性 〃	65.000	92.270	3.730	22.580	77.420	18.200	81.800	0.690	99.310	

BOTTOM

硫酸 SO_3	硅酸 SiO_2	燐酸 P_2O_5	炭酸 CO_2	クロール Cl	アンモニア NH_3	窒素 N	石灰 Ca	鐵 Fe	アルミニウム Al	ナトリウム Na	カリ K	マグネシウム Mg	硫黄 S
0.163	—	0.051	—	—	—	—	1.214	0.043	0.008	—	—	0.076	—
2.057	—	0.346	—	1.242	0.204	—	3.093	4.685	—	0.805	—	0.218	—
1.458	—	0.151	4.670	1.241	0.053	—	10.900	2.540	0.491	0.391	0.019	0.292	—
2.715	—	0.096	6.820	0.780	0.037	—	6.243	3.274	1.892	0.557	0.112	0.078	—
—	—	—	—	—	0.017	—	2.490	—	—	—	—	—	—
—	—	—	—	—	0.051	—	4.690	—	—	—	—	—	—
2.796	—	0.635	2.650	0.709	0.053	0.438	0.352	3.880	1.013	1.461	0.336	0.074	0.405
0.691	—	0.840	3.110	0.053	0.002	—	0.102	3.934	0.309	0.896	0.693	0	0.301
0.515	—	0.019	7.670	0.071	0	0	2.293	1.540	0.608	0.495	0.005	1.729	—
3.596	—	0.669	3.808	—	0.005	6.566	1.581	3.334	1.433	1.092	0.544	0.132	1.059
3.349	—	0.281	2.836	0.319	0.014	—	1.600	2.870	1.317	1.204	0.808	0.398	0.350
2.462	71.900	0.155	7.385	0.425	0.026	—	1.857	1.290	1.375	5 212	0.644	0.108	0.030
0.218	42.830	0.238	1.484	0.071	0.001	0.105	0.513	2.415	0.461	1.266	0	0.158	—
0.368	8.743	0.117	2.052	0.018	0.001	0.155	0.416	2 336	0.586	0.696	0	0.210	—
2.474	—	2.808	4.222	0.177	0.002	—	0.786	2.471	1.636	0.862	0.339	0.154	—
1.280	—	0.347	2.957	0.248	0.003	—	3.174	3.640	1.450	0.546	0.200	0.161	—
0.149	—	—	3.500	0.106	0.015	—	3.879	0.945	0.165	0.184	0.122	0.048	—
1.783	—	0.187	5.210	0.993	0	—	3.659	1.829	0.308	1.172	0.379	0.139	—
0.963	—	0.379	2.620	0.355	0.128	0.700	3 490	2.074	0.789	0.477	0.256	0.344	—
1.405	—	0.168	4.000	0.177	0.068	—	4.037	1.332	0.465	0.616	0.280	0.139	—
1.527	21.370	2.328	2.760	0.177	0.006	0.210	0.471	0.756	1.018	0.500	0.064	0.063	0.316
1.733	30.340	0.486	10.650	0.053	0.010	0.700	0.779	0.952	0.522	1.492	0.240	0.316	0.184
0.902	16.730	2.119	8.050	0.071	0.021	0.700	0.493	3 052	0.879	1.236	0.240	0.324	—
0.589	30.373	0.289	1.704	0.071	0	0.175	0.309	1.674	0.453	1.174	0.176	0.195	—
5.032	10.526	0.684	1.491	0.993	0.020	0.585	0.339	4.247	1.839	1.346	0.235	0.230	—
0.966	3.266	2.367	0.752	0.053	0.010	0.420	0.252	4.902	1.039	1.529	0.384	0.083	—
1.389	18.683	0.525	2.254	0.142	0.002	0.245	0.109	3.074	0.813	1.057	0.150	0.137	—
0.169	—	0.373	11.645	0.106	0.063	—	8.959	4.720	0.506	0.499	0.117	0.161	—
0.284	—	—	6.533	0.106	0.950	—	2.246	0.700	0.315	0.124	0.200	0.084	—
0.947	77.800	0.345	2 304	0.709	0.085	—	8.010	1.792	0.338	0.751	0.184	0.357	—
1.082	79.600	0.224	12.102	0.142	0.085	—	7.280	0 228	0.560	0.465	0.219	0.128	—
0.527	—	0.200	3.450	0.070	0.020	7.661	15.259	4.095	1.642	0.791	0.571	0.496	—
1.138	19.223	1.389	2.244	0.177	0.001	0.350	0.738	2.112	0.493	0.930	0.160	0.146	—
0.213	12.666	3.492	2.755	0.177	0.001	0.525	0.309	3.265	0.932	0.658	0.288	0.301	—
0.240	23.683	0.110	1.199	0.016	0.007	0.455	0.866	1.110	1.077	0.740	0.088	0.558	—
0.023	23.013	0.219	1.125	0.018	0.015	2.189	0.731	0.183	1.089	1.976	0.744	0.261	—
0.259	16.638	2.272	2.125	0.018	0	0.455	0.395	1.703	0.538	0.156	0.208	0.331	—
0.434	10.963	0.214	2.675	0.071	0.003	1.576	0.902	2.216	0.147	0.479	0.112	0.483	—
0.040	18.620	0.111	0.941	0.018	0	0.981	1.406	2.347	2.846	1.152	0.232	0.228	—
0.235	20.233	3.800	1.898	0.053	0.001	1.576	1.202	3.068	0.671	0.821	0.069	0.476	—
0.620	16.413	0.821	4.290	0.053	0.002	1.051	4.645	4.174	2.063	1.292	0.085	1.397	—
0.252	51.183	0.277	0.702	0.018	0.003	0.595	0.586	1.727	0.251	0.712	0.320	0.057	—
0.332	25 483	0.065	1.051	0.035	0	0.280	0.559	2.269	0.325	0.882	0.512	0.612	—
0.475	22.973	0.219	2.501	0.071	0.001	0.700	0.816	5.996	1.852	1.153	0.597	0.455	—
0.185	—	0.109	10.200	0.532	0	—	6.028	3.738	1.491	1.016	0.272	0.084	—
0.853	55.300	0.365	21.772	0.142	0.027	2.101	2.214	1.120	0.978	0.379	0.124	1.232	—

Index of Place

(1) Water.

No.

1 Nakamura fish-farm, Muroyoshida-mura, Aichi-ken.
2 Toyohashi-yogyo-shikenjyo, Kitajima near Toyohashi.
3 Maishiba-mura, Aichi-ken.
4 Toyohashi-yogyo-shikenjyo, Kitajima near Toyohashi.
5 ,, ,, ,, ,, ,, ,,
6 ,, ,, ,, ,, ,, ,,
7 Pond no. 1, Jinnoshinden-yogyo & Co. Ltd., Takashi-mura, Aichi-ken.
8 (II) Pond no A, 11, Jinnoshinden-yogyo & Co. Ltd., Takashi-mura, Aichi-ken.
9 ,, ,, 6, ,, ,, ,, ,, ,, ,, ,, ,,
10 Fish rearing pond of Toyohashi-yogyo-shikenjyo, Muro near Toyohashi.
11 Kaneno fish-farm, Muroyoshida-mura, Aichi-ken.
12 Pond no. 13, Jinnoshinden-yogyo & Co. Ltd., Takashi-mura, Aichi-ken.
13 ,, ,, 5, Amatsushinden-yogyo & Co. Ltd., Sugiyama-mura, Aichi-ken.
14 ,, ,, 6, ,, ,, ,, ,, ,, ,, ,, ,,
15 Fish rearing pond of Toyohashi-yogyo-shikenjyo, Mnro near Toyohashi.
16 Nakamura fish-farm, Muroyoshida-mura, Aichi-ken.
17 ,, ,, ,, ,, ,, ,, ,,
18 Pond no. 12, Jinnoshinden-yogyo & Co. Ltd., Takashi-mura, Aichi-ken.
19 Koiwai near Nakatsu, Oita.
20 River Sakura, Ibaragi-ken.
21 Takejiri, Gunchiku-mnra, Kumamoto-ken.
22 Branch of Kumamoto-fisheries-experiment-station, Gunchiku-mura, Kumamoto-ken.
23 Meijishinden, Gunchiku-mura, Kumamoto-ken.
24 River Rumo, Kumamoto-ken.
25 ,, ,, ,, ,,
26 Kinuura fish-farm, Takahama-mura, Aichi-ken.
27 Tokura fish-farm, Isshiki-machi, Aichi-ken.
28 ,, ,, ,, ,, ,, ,, ,,
29 Pond no. 18, Chūō fish-farm, Murakushi-mura, Shizuoka-ken.
30 ,, ,, 2, Hattorinakamura-yobetsu & Co. Ltd., Maisaka-machi, Shizuoka-ken.
,, ,, 5, ,, ,, ,, ,, ,, ,, ,, ,, ,,

No.

31 Nishimaruko fish-farm, Ubumi-mura, Shizuoka-ken.
32 Chūō fish-farm, Murakushi-mura, Shizuoka-ken.
33 Araiyogyo & Co. Ltd., Arai-machi, Shizuoka-ken.
34 Funai fish-farm, Takashi-mura, Aichi-ken.
35 Toyohashi-yogyo-shikenjyo, Kitajima near Toyohashi.
36 Pond no. 7, Atsuta-fish-farm, Nagoya.
37 „ „ 11, „ „ „ „
38 Muro irrigation, Ushikawa-mura, Aichi-ken.
39 „ „ near Toyohashi-gas-company, Toyohashi.
40 Fish rearing pond of Toyohashi-yogyo-shikenjyo, Muro near Toyohashi.
41 Entrance of Muro irrigation, Hitokuwada-mura, Aichi-ken.
42 Iwata-yogyo & Co. Ltd., Fukude-mura, Shizuoka-ken.
43 Lake Kizaki, Nagano-ken.
44 „ Awoki, „ „
45 River Nogu, Nagano-ken.
46 Kizaki-yogyo-shikenjyo, Taira-mura, Nagano-ken.
47 K. Yamamoto, Toyohashi.
48 Funai fish-farm, Takashi-mura, Aichi-ken.
49 „ „ „ „ „ „ „
50 Pond no. 6, Iwata-yogyo & Co. Ltd., Obo-mura, Shizuoka-ken.
51 „ „ 10, „ „ „ „ „ „ „ „ „
52 Funai fish-farm, Takashi-mura, Aichi-ken.
53 Toyohashi-yogyo-shikenjyo, Kitajima naer Toyohashi.
54 Pond no. 14, Chuo fish-farm, Murakushi-mura, Shizuoka-ken.
55 „ „ 17, of east division, „ „ „ „
56 „ „ 6, „ west „ „ „ „ „
57 „ „ „ „ east „ „ „ „ „
58 Toyohashi-yogyo-shikenjyo, Kitajima near Toyohashi.
59 K. Okada, Toyohashi.
60 K. Okada's tap water, Toyohashi.
61 Pond no. 13, Chuo fish-farm, Murakushi-mura, Shizuoka-ken.
62 „ „ „ „ „ „ „ „ „ „
63 Lake Hamana near Chuo fish-farm, Shizuoka-ken.
64 Pond no. 12, Chuo fish-farm, Murakushi-mura, Shizuoka-ken.

No.

65 Pond no. 10, Chuo fish-farm, Murakushi-mura, Shizuoska-ken.

66 „ „ 1, „ „ „ „ „ „ „

67 Y. Yoshiwara., Takashi-mura, Aichi-ken.

68 M. Kurono., Toyohashi.

69 River Shinhori, Hirosawa-mura, Gumma-ken.

70 Chuo fish-farm, Murakushi-mura, Shizuoka-ken.

71 S. Jinno., Toyohashi.

72 Pond no. 1, Jinnoshinden-yogyo & Co. Ltd., Takashi-mura, Aichi-ken.

73 (I) Pond no. 3, Jinnoshinden-yogyo & Co. Ltd., Takashi-mura, Aichi-ken.

73 (II) „ „ B3, „ „ „ „ „ „ „ „ „

74 Pond no. 1, Jinnoshinden-yogyo & Co. Ltd., Takashi-mura, Aichi-ken.

75 „ „ 3, „ „ „ „ „ „ „ „ „

76 „ „ 1, Moroto fish-farm, Kuwana.

77 Pond no. 1, Miye-yogyo & Co. Ltd., Kuwana.

78 Branch of Miye-yogyo & Co. Ltd., Ōyamada-mura, Miye-ken.

79 Itomi fish-farm, Isojima-mura, Miye-ken.

80 Asahi-kyodokeiyei fish-farm, Isojima-mura, Miye-ken,

81 Kikuyama-yogyo & Co. Ltd., Ueno-machi, Miye-ken.

82 Ozawa fish-farm, Kamezaki-shinden, Miye-ken.

83 Matsumoto fish-farm, „ „ „ „

84 Murakushi-mura, lake Hamana, Shizuoka-ken.

85 Ubumi-mura, lake Hamana, Shizuoka-ken.

86 Centre of Ubumi bridge, lake Hamana, Shizuoka-ken.

87 Tsutsumimaruyama fish-farm, near Kiriu, Gumma-ken.

88 Suzuki fish-farm, Sachiura-mura, Shizuoka-ken.

89 Small bay Shimono, lake Biwa, Shiga-ken.

90 S. Jinno Toyohashi.

91 M. Kusogami Muroyoshida-mura, Aichi-ken.

92 Small bay Matsubara, lake Biwa, Shiga-ken.

93 Pond no. 12, Shigaken-suisan-shikenjyo, near Hikone, Shiga-ken.

94 „ „ 6, „ „ „ „ „ „ „

95 Nakamura fish-farm, Hikone-machi, Shiga-ken.

96 Fish rearing pond no. 5 of Shiga-ken-suisan-shikenjyo, around Hikone castle.

97 Small bay Shimono, Lake Biwa, Shiga-ken.

No.

98 Shimizu seishijyo, Toyohashi.
99 Drain-water of Shimizu seishijyo, Toyohashi.
100 Pond no. 5, Chūō fish-farm, Murakushi-mura, Shizuoka-ken.
101 Masuda fish-farm, Yoshida-mura, Shizuoka-ken.
102 Naito fish-farm, Muroyoshida-mura, Aichi-ken.
103 Pond no. A4, Amatsushinden-yogyo & Co. Ltd., Sugiyama-mura, Aichi-ken.
104 Masuda fish-farm, Yoshida-mura, Shizuoka-ken.
105 Fish rearing pond of Toyohashi-yogyo-shikenjyo Muro near Toyohashi.
106 „ „ „ „ „ „ „ „ „ „
107 S. Mori Muroyoshida-mnra, Aichi-ken.
108 Kirido fish-farm, Shiotsu-mura, Aichi-ken.

(2) Bottom.

No.

1 Pond no. 5, Jinnoshinden-yogyo & Co. Ltd., Muroyoshida-mura, Aichi-ken.
2 „ „ 9, „ „ „ „ „ „ „ „ „
3 „ „ 13, „ „ „ „ „ „ „ „ „
4 „ „ 2, „ „ „ „ „ „ „ „ „
5 „ „ 12, „ „ „ „ „ „ „ „ „
6 „ „ 12, „ „ „ „ „ „ „ „ „
7 „ „ 10, Tokura fish-farm, Isshiki-machi, Aichi-ken.
8 „ „ 7, „ „ „ „ „ „ „
9 Nishimaruko fish-farm, Ubumi-mura, Shizoka-ken.
10 Pond no. 18, Chūō fish-farm, Murakushi-mura, Shizuoka-ken.
11 Ōhama fish-farm, Ōhama-machi, Aichi-ken.
12 Awa fish-farm, Tsuruoka-shinden, Tokushima-ken.
13 Naito fish-farm, Muroyoshida-mura, Aichi-ken.
14 Pond no. 7, Atsuta fish-farm, Nagoya.
15 „ „ 11, „ „ „ „
16 „ „ 11, „ „ „ „
17 Pond no. 22, Jinnoshinden-yogyo & Co. Ltd., Takashi-mura, Aichi-ken.
18 „ „ 5, „ „ „ „ „ „ „ „ „
19 Funai fish-farm, Takashi-mura, Aichi-ken.
20 Funai fish-farm, Takashi-mura, Aichi-ken.
21 „ „ „ „ „ „ „

No.

22 Pond no. 6, Iwata-yogyo & Co. Ltd., Obo-mura, Shizuoka-ken.
23 „ „ 16, Chūō fish-farm, Murakushi-mura, Shizuoka-ken.
24 „ „ 17, „ „ „ „ „ „ „
25 The Pond around castle, Saga.
26 Naito fish-farm, Muroyoshida-mura, Aichi-ken.
27 Miye-yogyo & Co. Ltd., Isojima-mura, Miye-ken.
28 Itomi fish-farm, Awoshigi-mura, Miye-ken.
29 Ozawa fish-farm, Kamezaki-shinden, Miye-ken.
30 Asahi-kyodokeiyei fish-farm, Shiohama-mura, Miye-ken.
31 Kikuyamayogyo & Co. Ltd., Ueno-machi, Miye-ken.
32 Matsumoto fish-farm, Ominato-machi, Miye-ken.
33 Miyeyogyo & Co. Ltd., Oyamada-mura, Miye-ken.
34 Estimated place of a fish-farm, lake Biwa, Shiga-ken.
35 „ „ „ „ „ „ „ „ „ „
36 „ „ „ „ „ „ „ „ „ „
37 Small bay Matsubara, lake Biwa, Shiga-ken.
38 „ „ „ „ „ „ „
39 Same as Water no. 96.
40 Pond no. 6, Shigaken-suisanshikenjyo, near Hikone, Shiga-ken.
41 „ „ 12, „ „ „ „ „ „
42 Pond no. 2, Nakamura fish-farm, Hikone-machi, Shiga-ken.
43 „ „ 5, Chūmei fish-farm, Murakushi-mura, Shizuoka-ken.
44 „ „ 9, „ „ „ „ „ „ „
45 Naito fish-farm, Muroyoshida-mura, Aichi-ken.
46 Masuda fish-farm, Yoshida-mura, Shizuoka-ken.

CHEMICAL STUDIES ON THE SILKWORM-PUPA AS FISH-FOOD. I.

The difference of chemical constitution of pupa on the sort of silkworm.

(Contributions from the Toyohashi Piscicultural Experiment Station No. 4.)

By

Oshima-Shinobu.

About thirty eight million kilogrammes of dried silkworm-pupa is produced yearly as a byproduct of silk industry in Japan. Almost all of it is used as fish-food or fertilisers. Pupa is used as fish-food in two ways: wet and dried; the wet one is that which is newly obtained after realing process, and the dried is that which has been dried. All of the samples I studied here are the wet one.

We may classify them into three kinds: the annual silkworm-pupa (Spring), the bivoltini silkworm-pupa (mainly Summer), and the polivoltini silkworm-pupa (mainly Autumn); and the amount of the production of the first kind attains about fifty five percent of all, the third being about thirty, and they can easily be distinguished on external appearance. It is the main object of my study to know the difference of chemical constitutions of these three kinks. The sorts of the sample are as follows:—

No.	Sort.	Survival period after mounting.	Solubility of sericin in the coccoon.
1.	Spring. No. 1, Sort of Japan.	9 days.	A little good.
2.	Spring. No. 4, No. 7, China.	9 ,,	Good.
3.	Spring. No. 1, Japan × No. 4, China.	9 ,,	Good.
4.	Spring. No. 7, No. 9, Europe.	9 ,,	Good.
5.	Summer. No. 107, Japan × No. 101, China.	9 ,,	No Good.
6.	Autumn. (No. 9 × No. 101) China × No. 107, Japan.	8 ,,	Good.

In the next place I studied the difference of chemical constitutions of pupa in the course of survival period after mounting. The sort of it is No. 6 (The Autumn pupa

Total N.	14.82	14.83	14.86	14.70	14.73
あまいど窒素 Amide N.	1.05	1.19	0.99	1.00	1.03
めらにん窒素 Melanin N.	0.27	0.35	0.36	0.37	0.37
ものあみの窒素 Mono-amino N.	9.64	9.50	9.61	9.58	9.52
ぢあみの窒素 Di-amino N.	3.85	3.84	3.84	3.81	3.84
ものあみの酸あみの窒素 Mono-amino acid amino N.	8.53	8.22	8.47	8.44	8.36
同 非あみの窒素 Do. Non amino N.	1.11	1.28	1.14	1.14	1.16
ぢあみの酸あみの窒素 Di-amino acid amino N.	2.33	2.28	2.31	2.27	2.31
同 非あみの窒素 Do. Non amino N.	1.52	1.56	1.53	1.54	1.53
ひすちぢん窒素 Histidine N.	0.87	0.88	0.88	0.88	0.89
りぢん窒素 Lysine N.	1.05	0.95	1.00	0.95	0.99
あるぎにん窒素 Arginine N.	1.88	1.94	1.89	1.91	1.88
しすちん窒素 Cystine N.	0.05	0.07	0.07	0.07	0.08

第 III 表

TABLE III.

上簇後生存日數ノ相違ニヨル蠶蛹成分百分率

Percentages of the chemical constituent in the silkworm-pupa (difference of the survival period after mounting).

上簇後生存日數 Survival period from mounting.	8 days		9 days		11 days		12 days		13 days		14 days	
物 matter.	% 32.98	% 100.00	% 32.75	% 100.00	% 31.95	% 100.00	% 31.09	% 100.00	% 30.05	% 100.00	% 29.14	% 100.00
粗灰分 Crude ash.	1.52	4.62	1.53	4.66	1.54	4.82	1.52	4.88	1.49	4.95	1.46	5.01
えーてる浸出物 Ether extract.	10.06	30.50	10.11	30.85	9.66	30.23	9.17	29.53	8.54	28.42	7.97	27.37
全窒素 Total N.	2.83	8.58	2.80	8.55	2.83	8.86	2.79	8.99	2.74	9.10	2.69	9.23
蛋白質窒素 Protein N.	2.53	7.67	2.49	7.60	2.52	7.89	2.47	7.96	2.41	8.03	2.38	8.15
非蛋白質窒素 Non protein N.	0.30	0.92	0.31	0.95	0.31	0.97	0.32	1.03	0.32	1.07	0.31	1.08
不溶性窒素 Insoluble N.	2.44	7.39	2.39	7.30	2.42	7.58	2.37	7.64	2.31	7.68	2.27	7.78
可溶性窒素 Soluble N.	0.39	1.19	0.41	1.25	0.41	1.29	0.42	1.35	0.43	1.42	0.42	1.45
蛋白質窒素 Protein N.	0.09	0.28	0.10	0.30	0.10	0.31	0.10	0.33	0.10	0.35	0.11	0.37
有機鹽基窒素 Basic N.	0.12	0.36	0.12	0.37	0.13	0.39	0.13	0.41	0.12	0.42	0.13	0.45
あんもにあ窒素 Ammonia N.	0.01	0.02	0.01	0.03	0.01	0.02	0.01	0.02	0.01	0.03	0.01	0.03
きちん窒素 Chitin N.	0.05	0.16	0.05	0.16	0.06	0.19	0.07	0.21	0.07	0.22	0.07	0.24
きちん窒素+こりおにん窒素 Chitin N. plus Chorionin N.	0.10	0.32	0.11	0.34	0.12	0.37	0.13	0.41	0.14	0.46	0.15	0.51

第 I 表

TABLE I.

品種ノ相違ニヨル蠶蛹ノ成分

Percentages of the chemical constituent in the silkworm-pupa.

品種 Sort of Silkworm.		日本種 1 號 (春蠶) No. 1 Japan. (Spring).		支那種 4 號, 7 號 (春蠶) No. 4, No. 7 China. (Spring).		日本種1號×支那種4號(春蠶) No. 1 Japan×No. 4 China. (Spring).		歐洲種 7 號, 9 號 (春蠶) No. 7, No. 9 Europe. (Spring).		日本種 107 號×支那種 101 號 (夏蠶) No. 107 Japan×No. 101 China. (Summer).		支那種 (9號×101號)×日本種 107 號 (秋蠶) (No. 9×No. 101) China×No. 107 Japan. (Autumn).	
物 matter.		33.48 %	100.00 %	33.69 %	100.00 %	35.39 %	10.000 %	32.77 %	100.00 %	30.67 %	100.00 %	32.98 %	100.00 %
灰分 ude ash.		1.38	4.13	1.56	4.64	1.53	4.32	1.32	4.02	1.17	3.83	1.52	4.62
ーてる浸出物 her extract.		10.59	31.62	10.75	31.91	11.35	32.07	10.78	32.90	9.24	30.13	10.06	30.50
窒素 otal N.		2.95	8.82	2.96	8.80	3.07	8.65	2.83	8.63	2.74	8.93	2.83	8.58
蛋白質窒素 Protein N.		2.61	7.89	2.50	7.43	2.73	7.71	2.52	7.68	2.46	8.05	2.53	7.67
非蛋白質窒素 Non Protein N.		0.34	0.93	0.46	1.37	0.34	0.94	0.31	0.95	0.28	0.88	0.30	0.92
不溶性窒素 Insoluble N.		2.52	7.54	2.40	7.11	2.64	7.46	2.45	7.47	2.42	7.88	2.44	7.39
可溶性窒素 Soluble N.		0.43	1.28	0.57	1.68	0.43	1.19	0.38	1.16	0.32	1.05	0.39	1.19
蛋白質窒素 Protein N.		0.09	0.25	0.11	0.32	0.09	0.25	0.07	0.21	0.05	0.16	0.09	0.28
有機鹽基窒素 Basic N.		0.08	0.23	0.10	0.31	0.05	0.14	0.09	0.27	0.08	0.27	0.12	0.36
あんもにあ窒素 Ammonia N.		0.01	0.02	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.02
きちん窒素 Chitin N.		0.10	0.30	0.11	0.32	0.14	0.39	0.07	0.23	0.07	0.23	0.05	0.16
きちん窒素＋こりおにん窒素 Chitin N. plus Chorionin N.		0.15	0.45	0.17	0.56	0.16	0.44	0.12	0.37	0.11	0.37	0.10	0.32
油ノ性質 ality of Oil.	酸價 Acid Value.	10.65		14.28		22.84		4.96		10.11		10.64	
	沃度價 Iodine Value.	87.08		91.18		86.32		86.56		49.61		77.50	

第 II 表

TABLE II.

蠶蛹蛋白質窒素ノ分布

Nitrogen distribution in the protein of silkworm-pupa.

品種 Sort of Silkworm.	日本種 1 號×支那種 4 號 (春蠶) No. 1 Japan×No. 4 China. (Spring).	日本種 107 號×支那種 101 號 (夏蠶) No. 107 Japan×No. 101 China. (Summer).	支那種(9 號×101 號)×日本種 107 號 (秋蠶) (No. 9×No. 101) China×No. 107 Japan. (Autumn).	同 Do.	同 Do.
上簇後生存日數 Survival period from mounting.	9 days	9 days	8 days	11 days	14 days
全窒素	%	%	%	%	%

All the samples used were obtained at the Toyokawa branch, Aichi-ken Sericultural Experiment Station and always prepared under the same treatment.

The nitrogen distribution of pupa's protein is estimated after the Van Slyke's method.

The results are shown as in Table. I–III.

The difference of six sorts of pupa accord to the differences of chemical constitutions. Among them the Spring-pupa is generally rich in dry matter especially in ether extract, but the Summer-pupa which requires longer time in realing, is poor in dry matter especially in ether-extract, while the Autumn-pupa ranks between them.

On the nitrogen distribution, there is no remarkable difference among the three kinds; but if it is compared with other edible Crustacea, we can see smaller quantity of total nitrogen as compared with the latter. This fact is due to the smaller quantity of diamino-acid.

Lastly, the longer the survival period after the mounting, the more the water is contained; at the same time, chitin and cholionin are increased more and more; on the contrary the ether-extract takes the remarkable decreasing rate.

As to the value of pupa as food, we can say the Spring-pupa is most valuable and Autumn-pupa stands in next; and as to the length of survival period, the shorter the length, the more it becomes valuable as food.

(Abstracted from the text written in Japanese.)

CHEMICAL STUDIES ON THE SILKWORM-PUPA AS FISH-FOOD. II.

The digestion of silkworm-pupa with protease of eels.

(Contributions from the Toyohashi Piscicultural Experiment Station No. 5.)

By

Oshima-Shinobu.

On other pages under a different title I have spoken about the wet and dried pupae which are used as food in fish-culture. Now I tried to examine the digestive

value in the wet and dried pupae in connection with protease of eels. The samples used are as follows :—

No. 1. Wet pupa. Autumn pupa. (No. 9 × No. 101) China ; × No. 107 Japan.

No. 2. Dried pupa. A. Autumn pupa. (No. 9 × No. 101) China ; × No. 107 Japan.

B. Summer pupa. No. 107 Japan ; × No. 101 China.

C. Spring pupa. No. 1 Japan ; × No. 101 China.

At first the materials were crushed into pieces by grinder, well rubbed out with a few water in a mortar and strained through a cloth ; then a few drops of truol were added to the mixture so as to make a liquid of a muscular suspension and a constant quantity of the liquid was taken as the material of the experiment. In the next place almost all the digestive organs of many eels were extracted in ordinary method and a constant quantity of the extract was taken. 10 c.cm. of each liquid thus prepared together with a proper quantity of water, N/10 hydrochloric acid, and N/10 sodium hydroxide were poured into a flask of 200 c.cm. in capacity as shown as in Table I, and corked and the mixture was put in a thermostat for 20 hours at the temperature of 33·5–36°C. After that time I added 10 c.cm. of tannic acid solution in them, (i.e. 100 grms. of tannic acid, 25 grms. of sodium aceticum, 35 grms. of sodium chloratum, 50 c.cm. of glacial acetic acid disolved in water of 1,000 c.cm.) in order to stop the digestive action and precipitated protein.

In the solution I estimated the quantity of the soluble nitrogen by Gunning method and amino-nitrogen by Van Slyke's micro-apparatus. On the measurement of hydrogen ion concentration, I adopted the Sorenzen's colorimetric method. The results are shown as in Table. II–IV.

In these results the protease of eels has its action on silkworm-pupa between pH 5.7 and 7.4, and seems to become more active in alkali within the limit of that hydrogen ion concentration.

In wet and dried pupae the former seem to be easily digestible but there is no marked difference for digestibility of pupae in the difference of seasons.

(Abstracted from the text written in Japanese.)

第 I 表　　TABLE I.

No.	1	2	3	4	5
水 Water.	20 瓦 c.cm.	19 瓦 c.cm.	18 瓦 c.cm.	19 瓦 c.cm.	18 瓦 c.cm.
鹽酸液 N/10 HCl Sol.	0	1	2	0	0
苛性曹達液 N/10 NaOH Sol.	0	0	0	1	2

第 II 表　　TABLE II.

消化前原料懸垂液 10 瓦中ノ窒素分布

Nitrogen distribution in 10 c.cm. of muscular suspension before the digestion.

品種 Sort.		全窒素 Total N.	蛋白質窒素 Protein N.	非蛋白質窒素 Non protein N.	あみの態窒素 Amino N.
No. I		0.03807 瓦 gm.	0.02569 瓦 gm.	0.01238 瓦 gm.	0.00263 瓦 gm.
No. II	A	0.03371	0.02439	0.00932	0.00182
	B	0.03546	0.02573	0.00973	0.00205
	C	0.04026	0.02901	0.01125	0.00248

第 III 表　　TABLE III.

消化後新生窒素ノ分布

Distribution of Nitrogen which newly produced after digestion.

品種 Sort.		No.	1	2	3	4	5
No. I		pH	6.6	6.2	5.7	6.9	7.4
		非蛋白質窒素 Non protein N.	0.00695 瓦 gm.	0.00776 瓦 gm.	0.00740 瓦 gm.	0.00663 瓦 gm.	0.00804 瓦 gm.
		あみの態窒素 Amino N.	0.00239	0.00252	0.00210	0.00211	0.00264
No. II	A	pH	6.7	6.4	6.0	7.0	7.4
		非蛋白質窒素 Non protein N.	0.00590	0.00636	0.00680	0.00565	0.00675
		あみの態窒素 Amino N.	0.00192	0.00219	0.00226	0.00190	0.00215
	B	pH	6.7	6.4	6.0	7.0	7.4
		非蛋白質窒素 Non protein N.	0.00630	0.00638	0.00715	0.00588	0.00728
		あみの態窒素 Amino N.	0.00201	0.00213	0.00230	0.00193	0.00229
	C	pH	6.7	6.4	6.0	7.0	7.4
		非蛋白質窒素 Non protein N.	0.00667	0.00731	0.00818	0.00682	0.00852
		あみの態窒素 Amino N.	0.00227	0.00251	0.00280	0.00232	0.00284

第 IV 表　　TABLE IV.

No.			1	2	3	4	5
非蛋白質窒素 / 蛋白質窒素 Non Protein N. / Protein N.	No. I		27.2 %	30.2 %	28.8 %	25.8 %	31.3 %
	No. II	A	24.2	26.1	27.9	23.2	27.7
		B	24.5	24.8	27.8	22.9	28.3
		C	23.0	25.2	28.2	23.5	29.4
あみの態窒素 / 蛋白質窒素 Amino N. / Protein N.	No. I		9.3	9.8	8.2	8.2	10.3
	No. II	A	7.9	9.0	9.5	7.8	8.8
		B	7.8	8.3	9.0	7.5	8.9
		C	7.8	8.7	9.7	8.0	9.8

第 I 表 TABLE I.

溫 度 觀 測 表

Experiment temperature.

日付 Date.	10月 14日 Oct. 14				10月 15日 Oct. 15				10月 16日 Oct. 16			
時間 Time.	正午 Noon	午後3時 3 p.m.	午後6時 6 p.m.		午前9時 9 a.m.	正午 Noon	午後3時 3 p.m.	午後6時 6 p.m.	午前9時 9 a.m.	正午 Noon	午後3時 3 p.m.	午後6時 6 p.m.
水浸物 Temp. of dipped sample.					19.2	19.4	19.7	20.2	18.3	18.9	19.6	20.0
非水浸物 Temp. of non dipped sample.					20.8	21.4	22.4	23.8	20.8	21.9	22.7	24.0
氣溫 Atmospheric temperature.	20.9	20.6	19.4		19.0	21.0	21.0	16.5	18.3	21.0	22.2	17.4
日付 Date.	10月 17日 Oct. 17				10月 18日 Oct. 18				10月 19日 Oct. 19			
時間 Time.	午前9時 9 a.m.	正午 Noon	午後3時 3 p.m.	午後6時 6 p.m.	午前9時 9 a.m.	正午 Noon	午後3時 3 p.m.	午後6時 6 p.m.	午前9時 9 a.m.	正午 Noon	午後3時 3 p.m.	午後6時 6 p.m.
水浸物 Temp. of dipped sample.	18.0	18.9	20.0	20.2	17.0	18.2	19.8	20.2	19.0	19.7	20.3	20.5
非水浸物 Temp. of non dipped sample.	20.2	21.0	23.5	25.3	20.0	20.7	22.6	25.3	21.0	22.3	23.8	25.6
氣溫 Atmospheric temperature.	14.0	22.0	24.0	20.0	19.6	22.5	23.0	20.1	19.3	23.3	22.1	20.5
日付 Date.	10月 20日 Oct. 20				10月 21日 Oct. 21				10月 22日 Oct. 22			
時間 Time.	午前9時 9 a.m.	正午 Noon	午後3時 3 p.m.	午後6時 6 p.m.	午前9時 9 a.m.	正午 Noon	午後3時 3 p.m.	午後6時 6 p.m.	午前9時 9 a.m.	正午 Noon	午後3時 3 p.m.	
水浸物 Temp. of dipped sample.	18.7	19.2	20.1	20.5	18.2	19.6	20 0	20.5	17.5	18.7	20.0	
非水浸物 Temp. of non dipped sample.	21.0	22.0	24.0	25.8	23.1	24.0	24.6	26.3	23.8	24.1	24.5	
氣溫 Atmospheric temperature.	22.0	22.0	23.4	18.0	19.0	21.6	21.3	16.5	18.2	22.8	23.4	

第 II 表 TABLE II.

生蛹貯藏中ノ成分變化

Chemical change of wet pupa in storing.

試料 Sample.	原料 Raw sample	水浸物 Dipped sample				非水浸物 Non dipped sample.			
經過日數 No. of days.	0	2	4	6	9	2	4	6	9
水分及浸出成分 Water & extracted matter.	66.63%	67.78%	69.70%	69.98%	70.84%	66.98%	67.67%	68.38%	68.95%
殘留物 Residual matter.	33.37	32.22	30.30	30.02	29.16	33.02	32.33	31.62	31.05
粗灰分 Crude ash.	1.09	0.89	0.73	0.69	0.64	1.05	1.05	1.04	1.04
えーてる浸出物 Ether extract.	10.86	10.48	9.99	9.86	9.85	10.78	10.48	10.08	10.04
きちん Chitin.	0.81	0.82	0.81	0.81	0.82	0.82	0.80	0.82	0.82

全窒素 Total N.	2.84	2.64	2.33	2.26	2.08	2.75	2.61	2.49	2.39
蛋白質窒素 Protein N.	2.60	2.42	2.13	2.06	1.85	2.47	2.34	2.01	1.76
非蛋白質窒素 Non protein N.	0.24	0.22	0.20	0.20	0.23	0.28	0.27	0.48	0.63
不溶性窒素 Insoluble N.	2.32	2.16	1.91	1.85	1.69	2.10	1.91	1.69	1.36
可溶性窒素 Soluble N.	0.52	0.48	0.42	0.41	0.39	0.65	0.70	0.80	1.03
蛋白質窒素 Protein N.	0.29	0.25	0.21	0.20	0.17	0.31	0.32	0.32	0.40
有機鹽基窒素 Basic N.	0.09	0.10	0.10	0.11	0.12	0.16	0.20	0.27	0.35
あみの窒素 Amino N.	0.10	0.09	0.09	0.08	0.08	0.10	0.10	0.10	0.10
あんもにあ態窒素 Ammonia N.	0.01	0.01	0.02	0.02	0.02	0.03	0.02	0.03	0.03
抽出油之性質 Quality of extracted oil. 色彩 Colour.	黄 Yellow	橙黄 Orange yellow	黄褐 Orange brown	褐 Brown	赤褐 Red brown	橙 Orange	黄褐 Orange brown	赤褐 Red brown	赤褐 Red brown
酸價 Acid value.	37.2	122.4	179.2	188.4	189.5	153.4	187.4	188.2	190.9
鹸化價 Saponification value.	197.2	195.2	196.6	196.8	194.2	196.7	198.2	198.5	203.4
沃度價 Iodine value.	138.5	134.1	129.7	126.6	127.6	131.6	127.4	124.5	116.5
らいへるとまいする價 Reicher Meisslt number.	2.102	1.563	1.728	1.481	1.591	2.052	3.415	4.104	3.927

第 III 表 TABLE III.

乾燥蛹貯藏中ノ成分變化（純乾物中）

Chemical change of dried pupa in storing.

經過日數 No. of days.		0	90	180	270	360
粗灰分 Crude ash.		% 4.15	% 4.20	% 4.22	% 4.25	% 4.31
えーてる浸出物 Ether extract.		31.95	31.65	31.84	31.72	31.17
全窒素 Total N.		8.66	8.67	8.64	8.65	8.62
蛋白質窒素 Protein N.		7.59	7.53	7.54	7.58	7.62
非蛋白質窒素 Non protein N.		1.07	1.14	1.10	1.07	1.00
不溶性窒素 Insoluble N.		7.35	7.37	7.35	7.34	7.34
可溶性窒素 Soluble N.		1.31	1.30	1.29	1.31	1.28
蛋白質窒素 Protein N.		0.24	0.26	0.19	0.24	0.28
有機鹽基窒素 Basic N.		0.23	0.31	0.27	0.29	0.32
きちん窒素 Chitin N.		0.29	0.30	0.30	0.32	0.34
抽出油ノ性質 Quality of extracted oil.	酸價 Acid value.	24.43	33.41	52.65	63.53	71.58
	沃度價 Iodine value.	123.7	120.3	115.7	112.2	108.6

CHEMICAL STUDIES ON THE SILKWORM-PUPA AS FISH-FOOD. III.

A chemical change of stored pupae.

(Contributions from the Toyohashi Piscicultural Experiment Station No. 6.)

By

Oshima-Shinobu.

In using the pupae as fish-food in a fish-culture it is often necessary to store wet pupae for a few days and dried ones for a few month. I tried to know a change of chemical constitutions during that period.

Wet pupa. An every constant quantity of wet pupae was put in eight glass bottles and it was put under pressure a little. To four of them water was poured in the same quantity as the volume of pupae as it is usual to do so in using them as food of fishes. During the experiment temperature was carefully noted down which are shown in table. I.

Then I weighed the quantity and inspected a change of chemical constitutions of pupae during the period of the storing; by this way I tried to know the remaining constitutions and the rate of change. (Table. II.)

Dried pupa. The dried pupae were crushed into powder and put in a glass bottle, the mouth of which was tightly covered with wire guage and cloth as to prevent the entrance and damage of insects. And I studied the chemical constitutions of it after the lapse over one year. The result is as shown as in table. III.

During the period of storing, the wet pupae undergo decomposition within a few days at the beginning of the experiment and lost their value as fish-nutrition as the time passes as showe in the table II. In the dipped and non-dipped pupae the latter decompose more quickly than the former.

The dried pupae decompose slowly in the lapse of time, as it is proved in the increase of acid value of extracted oil, gradually decreasing of the quantity of ether-extract and the increase of crude ash and chitin.

(Abstracted from the text written in Japanese.)

ON THE SEASONAL CHANGE OF TEE CHMICAL CONSTITUTION OF MUSCLE OF CARPS.

(Contributions from the Toyohashi Piscicultural Experiment Station No. 7.)

By

Oshima-Shinobu.

Already we know that the spawning season and the difference of sex have a great influence on the chemical constitutions of fish muscle. I have studied the seasonal change of the chemical constitutions of muscle of carps though one year. The carps used as material have been fed in a fish pond from March to November every year. I have adopted the Van Slyke's method for the analysis of the muscle protein. The results are as shown as in Table I–III.

The dry matter is least in the quantity during the spawning season, and from that time on it increases greatly untill November when it reaches in its highest quantity; but it gradually decreases again after the fasting season. The quantity of dry matter differs between sexes, female having almost always more dry matter than male except in November. The ether-extract shows almost the same result as dry matter, but in this case it is not in November but in August that its quantity becomes largest. The seasonal change of the total-nitrogen is quite the same as the dry matter, and male contain it more than female. Every form of nitrogen changes nearly in the same manner as the total nitrogen.

In the constitution of the muscle protein, the total nitrogen is largest in quantity in August, smallest in March, and male have always more than female but only a little. But it is not always the case with the elements which constitute it. The total quantity of mono-amino-acid is the greatest in May in male, while so in March in female; and in both cases, generally saying, it is great in Spring and less in Autumn, di-amino-acid being vice versa.

Among the whole form of nitrogen in the di-amino-acid, Cystine hardly changes in its quantity through the year, female however having more tendency to change than male. Arginine and Lysine are much in male than in female, the former reaching in its highest quantity in Summer and Autumn, the latter in the spawning season, that is

第 I 表 TABLE I.

鯉 肉 成 分

Chemical Composition of Muscle of Carps in different seasons.

月別 Month.	8月 August.		11月 November.		3月 March.		5月 May.	
性別 Sex.	♂	♀	♂	♀	♂	♀	♂	♀
水分 Water.	78.20	76.03	74.22	74.26	79.21	78.46	80.57	80.13
乾物 Dry matter.	21.80	23.97	25.78	25.74	20.79	21.54	19.43	19.87
粗灰分 Crude ash.	1.21	1.03	1.28	1.39	1.15	1.12	1.01	1.18
えーてる浸出物 Ether extract.	2.30	5.74	2.07	2.41	1.50	1.95	1.31	2.66
全窒素 Total N.	2.96	2.69	3.48	3.34	2.88	2.75	2.48	2.46
蛋白質窒素 Protein N.	2.38	2.13	2.81	2.69	2.40	2.33	2.05	2.08
非蛋白質窒素 Non protein N.	0.58	0.55	0.68	0.65	0.47	0.42	0.43	0.38
可溶性窒素 Soluble N.	0.96	0.89	1.11	1.09	0.81	0.82	0.73	0.75
蛋白質窒素 Protein N.	0.38	0.34	0.44	0.44	0.34	0.40	0.30	0.37
有機鹽基窒素 Basic N.	0.25	0.22	0.29	0.29	0.18	0.17	0.18	0.18
あみの態窒素 Amino N.	0.12	0.11	0.13	0.13	0.10	0.10	0.09	0.09

第 II 表 TABLE II.

鯉肉蛋白中ノ窒素ノ分布

Nitrogen distribution in the Protein of Muscle of Carps in different seasons.

月別 Month.	8月 August.		11月 November.		3月 March.		5月 May.	
性別 Sex.	♂	♀	♂	♀	♂	♀	♂	♀
全窒素 Total N.	16.29	16.22	16.22	16.14	16.06	16.02	16.25	16.21
ものあみの酸窒素 Mono-amino acid N.	9.54	9.61	9.65	9.52	9.76	9.86	9.78	9.78
ぢあみの酸窒素 Di-amino acid N.	5.12	4.95	5.18	4.86	4.97	4.81	4.97	4.83
あんもにあ窒素 Ammonia N.	0.86	0.91	0.90	0.90	0.85	0.93	0.85	0.82
めらにん窒素 Melanin N.	0.77	0.76	0.75	0.84	0.49	0.57	0.65	0.78
ぢあみの酸窒素 Di-amino acid amino N.	3.08	2.91	3.07	2.86	3.02	2.86	3.03	2.88
ぢあみの酸非あみの窒素 Di-amino acid non amino N.	2.04	2.04	2.11	2.00	1.94	1.95	1.94	1.96
ものあみの酸あみの窒素 Mono-amino acid amino N.	8.65	9.05	8.57	9.00	8.92	9.25	9.02	9.25
ものあみの酸非あみの窒素 Mono-amino acid non amino N.	0.89	0.56	1.08	0.53	0.84	0.60	0.76	0.54
しすちん窒素 Cystine N.	0.05	0.06	0.05	0.06	0.06	0.06	0.05	0.06
あるぎにん窒素 Arginine N.	2.20	2.10	2.27	2.09	2.07	2.03	2.06	2.02
ひすちぢん窒素 Histidine N.	1.41	1.49	1.46	1.43	1.36	1.40	1.37	1.42
りぢん窒素 Lysine N.	1.46	1.30	1.40	1.28	1.47	1.32	1.50	1.34

第 III 表 TABLE III.

あみの窒素ト非あみの窒素トノ比率

Amino nitrogen divided by non amino nitrogen.

月別 Month.	8月 August.		11月 November.		3月 March.		5月 May.	
性別 Sex.	♂	♀	♂	♀	♂	♀	♂	♀
ものあみの酸 Mono-amino acid.	9.77	16.22	7.91	17.04	10.65	15.39	11.95	17.28
ぢあみの酸 Di-amino acid.	1.51	1.43	1.46	1.43	1.55	1.47	1.56	1.47

to say in May. Histidine, on the contrary, is much in female, and in Summer and Autumn it reaches its highest quantity. Melanine is very poorly in March.

(Abstracted from the text written in Japanese.)

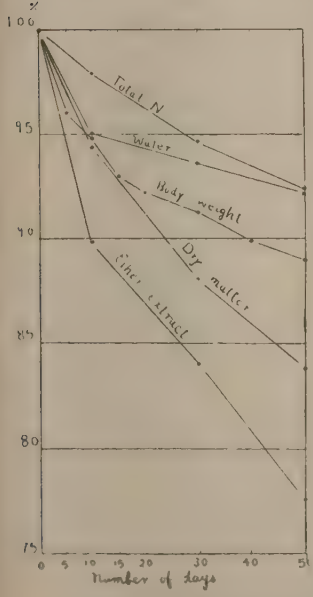
ON THE CHEMICAL CHANGE OF THE EELS IN THE COURSE OF FASTING.

(Contributions from the Toyohashi Piscicultural Experiment Station No. 8.)

By

Oshima-Shinobu.

The eels feeded in a fish pond are usually employed for cooking after a few days of fasting. So, I examined the decreasing quantity of their body weight and constituent in the course of fasting. The material I have taken had been chiefly fed on dried silkworm-pupae, fully grown up to an edible size. Three days after catching at 22nd, October, 1926, the experiment began, and continued to 11th December the same year. In the course of the fity days of the study, the temperature of water was estimated every day; because the temperature of water has a great effect on the vital phenomena of the fish. The result of the estimation of body weight which has been taken eight times is arranged in table II. Analysis has been done four times during the period, which showed the chemical constitutions of eels at each time, being given in table III. Table IV shows the decreasing quantity of each constituent of eels by calculation.



During the fasting period, eels gradually lessen their weight; and the rate of the lessening is large at the beginning of period, then decrease by degrees. This fact is

due to the consumption of their constituent, but the rate of consumption is not equal in each constituent and in each period. In water and dry matter, the latter is more consumed, consequently the more the fasting period continues, the more the difference of quantity increases. In dry matter, ether-extract consumpts much, but crude ash decreases very little; the rate of decreasing of total nitrogen is a little more than that of water. Non-protein nitrogen or soluble-nitrogen has higher rate of decreasing than protein-nitrogen or insoluble-nitrogen. Therefore the decreasing of body weight is mainly due to the decreasing of dry matter; and the decreasing of dry matter is mostly due to the decreasing of ether-extract.

(Abstracted from the text written in Japanese.)

第 I 表　　TABLE I.

水 溫 觀 測 表

Water temperature in the course of fasting.

時間 Time.		10 月 Oct. 下旬 Last decade.	11 月 Nov. 上旬 Beginning decade.	11 月 Nov. 中旬 Middle decade.	11 月 Nov. 下旬 Last decade.	12 月 Dec. 上旬 Beginning decade.
午前 8 時 8. A.M.	最高 Maximum.	16.0 C.	13.0 C.	13.2 C.	10.1 C.	10.9 C.
	最低 Minimum.	13.6	9.5	9.6	6.7	4.2
	平均 Average.	14.8	11.5	11.2	8.6	8.0
午後 2 時 2. P.M.	最高 Maximum.	21.1	17.1	17.8	12.7	12.4
	最低 Minimum.	15.4	13.1	11.8	10.7	6.1
	平均 Average.	17.9	15.2	14.6	11.7	10.6
午後 5 時 5. P.M.	最高 Maximum.	20.2	16.3	17.8	12.2	12.6
	最低 Minimum.	15.0	13.0	11.9	10.3	6.1
	平均 Average.	17.3	14.6	14.2	11.4	9.8

第 II 表　　TABLE II.

體 重 測 定 表

Body weight and its decreasing quantity.

月日 Date.	經過日數 No. of days.	Description.		No. 1	2	3	4	5	6	7	8	減少率平均 Average.	一日平均減少率 Decreasing rate per day.
10 月 22 日 Oct. 22	0	體重 Body weight.	瓦 gm.	208.3	163.5	150.0	149.4	148.6	135.1	132.8	126.8		
10 月 27 日 Oct. 27	5	體重 Body weight.	瓦 gm.	197.5	157.0	144.0	143.4	142.9	129.5	127.6	122.3		
		生込當初ニ對スル減少量 Decreased quantity.	瓦 gm.	10.8	6.5	6.0	6.0	5.7	5.6	5.2	4.5		
		同上百分比 Decreased quantity divided by beginning body weight.	%	5.18	3.97	4.00	4.02	3.83	4.15	3.92	3.55	4.08	0.816
11 月 1 日 Nov. 1	10	體重 Body weight.	瓦 gm.	196.2	154.7	142.5	142.4	141.4	128.3	124.8	120.6		
		生込當初ニ對スル減少量 Decreased quantity.	瓦 gm.	12.1	8.8	7.5	7.0	7.2	6.8	8.0	6.2		
		同上百分比 Decreased quantity divided by beginning body weight.	%	5.81	5.38	5.00	4.68	4.84	5.03	6.03	4.89	5.21	0.226
11 月 6 日 Nov. 6	15	體重 Body weight.	瓦 gm.	192.8	153.2	140.2	138.6	138.5	125.9	121.6	118.0		
		生込當初ニ對スル減少量 Decreased quantity.	瓦 gm.	15.5	10.3	9.8	10.8	10.1	9.2	11.2	8.8		
		同上百分比 Decreased quantity divided by beginning body weight.	%	7.44	6.30	6.53	7.23	6.80	6.81	8.44	6.94	7.06	0.370
11 月 11 日 Nov. 11	20	體重 Body weight.	瓦 gm.	190.8	150.8	139.5	138.4	137.0	125.6	120.8	116.9		
		生込當初ニ對スル減少量 Decreased quantity.	瓦 gm.	17.5	12.7	10.5	11.0	11.6	9.5	12.0	9.9		
		同上百分比 Decreased quantity divided by beginning body weight.	%	8.40	7.77	7.00	7.36	7.81	7.03	9.04	7.81	7.78	0.144
11 月 21 日 Nov. 21	30	體重 Body weight.	瓦 gm.	187.2	150.5	138.3	138.0	135.0	124.7	118.8	115.2		
		生込當初ニ對スル減少量 Decreased quantity.	瓦 gm.	21.1	13.0	11.7	11.4	13.6	10.4	14.0	11.6		
		同上百分比 Decreased quantity divided by beginning body weight.	%	10.13	7.95	7.80	7.63	9.15	7.70	10.54	9.15	8.76	0.098
12 月 1 日 Dec. 1	40	體重 Body weight.	瓦 gm.	185.3	148.0	137.6	135.8	131.6	123.2	115.1	114.6		
		生込當初ニ對スル減少量 Decreased quantity.	瓦 gm.	23.0	15.5	12.4	13.6	17.0	11.9	17.7	12.2		
		同上百分比 Decreased quantity divided by beginning body weight.	%	11.04	9.48	8.27	9.10	11.44	8.81	13.32	9.62	10.14	0.138
12 月 11 日 Dec. 11	50	體重 Body weight.	瓦 gm.	183.4	147.3	136.5	133.9	129.8	122.9	114.0	112.2		
		生込當初ニ對スル減少量 Decreased quantity.	瓦 gm.	24.9	16.2	13.5	15.5	18.8	12.2	18.8	14.6		
		同上百分比 Decreased quantity divided by geginning body weight.	%	11.95	9.90	9.00	10.37	12.65	9.03	14.16	11.52	11.07	0.093

第十表

第十一表

第 III 表 TABLE III.

生込中ニ於ケル鰻體成分
Percentages of the chemical constituent in the eels during the fasting period.

月日 Date.	10月22日 Oct. 22	11月1日 Nov. 1	11月21日 Nov. 21	12月11日 Dec. 11
經過日數 No. of days.	0	10	30	50
水分 Water.	% 57.89	% 58.06	% 59.36	% 60.19
乾物 Dry matter.	42.11	41.94	40.64	39.81
粗灰分 Crude ash.	1.76	1.80	1.83	1.93
えーてる浸出物 Ether extract.	23.80	22.54	21.93	20.82
全窒素 Total N.	2.62	2.71	2.71	2.72
蛋白質窒素 Protein N.	2.30	2.38	2.39	2.41
非蛋白質窒素 Non protein N.	0.32	0.33	0.32	0.31
不溶性窒素 Insoluble N.	2.01	2.03	2.09	2.12
可溶性窒素 Soluble N.	0.61	0.68	0.74	0.60
蛋白質窒素 Protein N.	0.29	0.35	0.30	0.29
有機鹽基窒素 Basic N.	0.16	0.15	0.15	0.17
あみの態窒素 Amino N.	0.13	0.17	0.17	0.17

第 IV 表 (1) TABLE IV. (1)

生込中ニ於ケル鰻體成分減耗表
Decreasing quantity of each constituents in the eels during the fasting period.

經過日數 No. of days.	0	10			30			50		
類別 Description.	百分率 Percentages.	當初ノ重量ニ對スル百分率 Percentages in the table III, multiplied by the rate of decreased body weight.	減耗率 Decreasing rate.		當初ノ重量ニ對スル百分率 Percentages in the table III, multiplied by the rate of decreased body weight.	減耗率 Decreasing rate.		當初ノ重量ニ對スル百分率 Percentages in the table III, multiplied by the rate of decreased body weight.	減耗率 Decreasing rate.	
			A—B	C/A		A—D	E/A		A—F	G/A
	A	B	C		D	E		F	G	
水分 Water.	% 57.89	% 55.03	% 2.86	% 4.94	% 54.18	% 3.71	% 6.41	% 53.37	% 4.52	% 7.81
乾物 Dry matter.	42.11	39.75	2.36	5.60	37.09	5.02	11.92	35.30	6.81	16.17
粗灰分 Crude ash.	1.76	1.66	0.10	5.68	1.67	0.09	5.11	1.72	0.04	2.27
えーてる浸出物 Ether extract.	23.80	21.37	2.43	10.21	20.01	3.79	15.92	18.46	5.34	22.44
全窒素 Total N.	2.62	2.56	0.06	2.29	2.48	0.14	5.34	2.42	0.20	7.63
蛋白質窒素 Protein N.	2.30	2.25	0.05	2.17	2.18	0.12	5.22	2.14	0.16	6.96
非蛋白質窒素 Non protein N.	0.32	0.31	0.01	3.13	0.30	0.02	6.25	0.28	0.04	12.50
不溶性窒素 Insoluble N.	2.01	1.92	0.09	4.48	1.91	0.10	4.97	1.89	0.12	5.97
可溶性窒素 Soluble N.	0.61	0.64			0.57	0.04	6.56	0.53	0.08	13.11

第 IV 表 (2) TABLE IV. (2)

當該期間一日平均主要成分減耗表
Decreasing rate per day.

類別 Description.	A—B	C/A	A—D	E/A	A—F	G/A
日數 No. of days.	自 10月22日 至 11月1日 10日間 From Oct. 22nd to Nov. 1st.		自 11月2日 至 11月21日 20日間 From Nov. 2nd to Nov. 21st.		自 11月22日 至 12月11日 20日間 From Nov. 22nd to Dec. 11th.	
體重 Body weight.		% 0.5210		% 0.1775		% 0.1155
水分 Water.	% 0.2860	% 0.4940	% 0.0425	% 0.0735	% 0.0405	% 0.0700
乾物 Dry matter.	0.2360	0.5600	0.1330	0.3160	0.0895	0.2130
えーてる浸出物 Ether extract.	0.2430	1.0210	0.0680	0.2860	0.0775	0.3260
全窒素 Total N.	0.0060	0.2290	0.0040	0.1530	0.0030	0.1150